The Climate Change Challenge

Actions New Hampshire Can Take to Reduce Greenhouse Gas Emissions

December 2001

New Hampshire Department of Environmental Services

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December 2001

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OVERVIEW

The Climate Change Challenge was prepared by the New Hampshire Department of Environmental Services to provide recommendations for the State to reduce emissions of greenhouse gases. It was crafted with input from legislators, business and industry, environmentalists, government agencies, educators, researchers, and other stakeholders and interested parties through their participation in an external workgroup. *The Climate Change Challenge* identifies over 70 recommendations that can be implemented by individuals, businesses and government through a combination of voluntary and regulatory approaches.

Complex interactions between the sun's energy, and the oceans, continents, atmosphere, and living things drive the earth's climate. Some of the sun's energy absorbed by the earth is radiated back into the atmosphere and is absorbed by gases such as water vapor, carbon dioxide, methane, halocarbons, ozone, and nitrous oxide (known as "greenhouse gases"). These heat-trapping gases in turn radiate heat back to the earth further warming the surface. This so-called "greenhouse effect" maintains the earth's surface temperatures at levels that are conducive to life, as we know it. Recent increases in the concentration of some of these greenhouse gases particularly carbon dioxide (CO_2) are significantly intensifying this effect, altering the earth's climate.

Scientists have confirmed that global surface temperatures have increased an average of 1^{o} F over the 20^{th} century. There is also now strong scientific consensus that this observed warming is attributable to human activities, predominantly increased fossil fuel combustion and changes in land use.[1] Although some scientific uncertainty remains as to the degree that the temperature will change and when these changes will occur, there is consensus among the overwhelming majority of scientists that concentrations of greenhouse gases are increasing at an unprecedented rate, and that changes in the earth's climate are now underway and will continue.

Scientists predict that climate change will result in a rise in the sea level, an increase in the number of extreme storm events, disruption of fresh water and food supplies, impacts to the vitality and health of forests and other natural areas, and potential impacts to human health and wildlife. New Hampshire's quality of life is directly tied to its lakes, rivers, ocean shoreline, mountains, hardwood forests (which produce brilliant fall foliage), scenic towns, and other natural areas. New Hampshire's economy relies heavily on tourism, as millions visit New Hampshire every year to enjoy the State's natural resources. An increase in average temperature in New Hampshire will impact the characteristics of its forests and water resources, altering plant and animal species, and may have a detrimental effect on public health. Examples of industries that may, over time, be directly impacted by global climate change include tourism, forestry, forest products (e.g., wood and paper), maple syrup/sugar production, skiing, and fishing.

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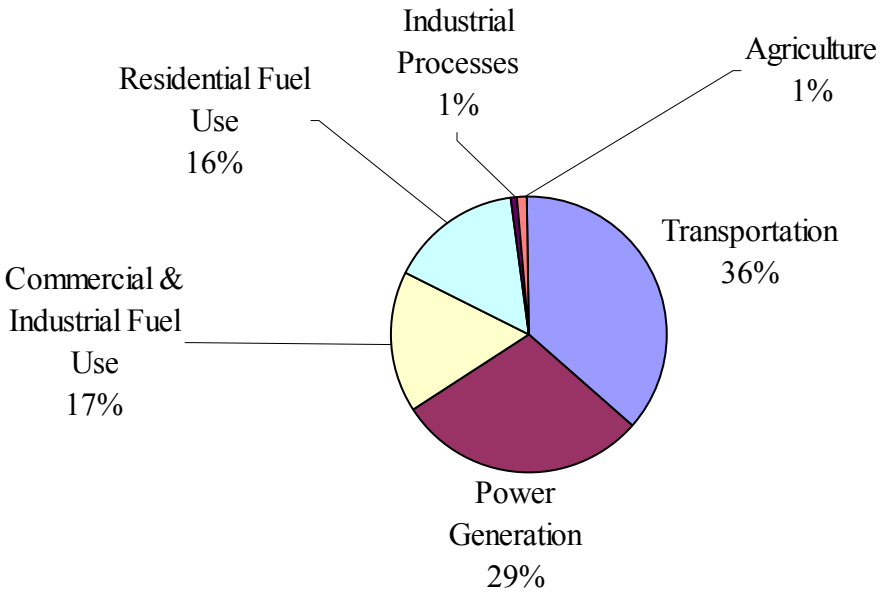
[1] The discussion of climate change science throughout this chapter is drawn extensively from the U.S. Global Change Research Program, U.S. National Assessment Synthesis Team, 2000, *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change, s*ee http://www.usgcrp.gov .

Warmer temperatures may also result in an increased incidence of heat-related illnesses and vector-borne diseases such as encephalitis and Lyme disease. As a result of these impacts, the public could be faced with increased health costs, additional municipal costs due to infrastructure damage from erosion and storm damage, and loss of jobs and revenues from impacts to certain industries.

While there are other sources of greenhouse gases, energy production and use generates more than 90% of the total greenhouse gas emissions in New Hampshire, and are a major focus of this report. Based on New Hampshire's 1993 Greenhouse Gas emissions inventory, the predominant greenhouse gases emitted in New Hampshire are carbon dioxide (92%), methane (7%), and nitrous oxide (1%). Sources of these greenhouse gases include transportation, energy production and use, landfills, agricultural activities (including livestock) and natural gas distribution.

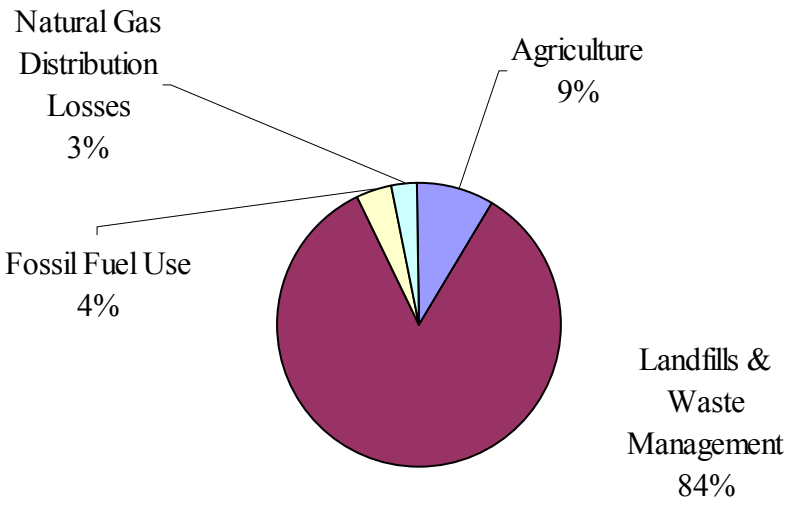
FIGURE O-1. Sources of Carbon Dioxide (CO_2) Emissions in New Hampshire



Source: New Hampshire Greenhouse Gas Inventory[2]

[2] NH Department of Environmental Services, *The New Hampshire 1993 Greenhouse Gas Inventory*, October 1997 http://www.des.state.nh.us/ard/ghgi/.

FIGURE O-2. Sources of Methane (CH_4) Emissions in New Hampshire

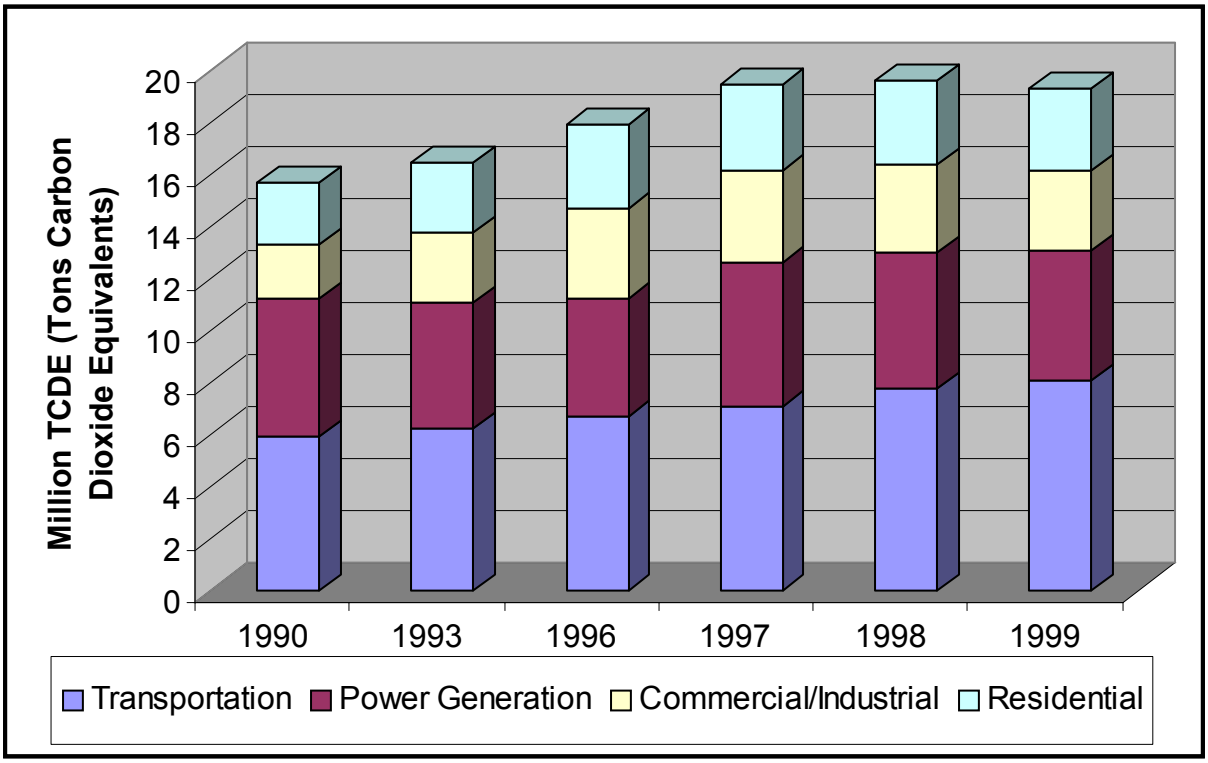


Source: New Hampshire Greenhouse Gas Inventory[3]

As previously mentioned, energy production and use generates most of the greenhouse gas emissions in New Hampshire, responsible for approximately 93% of the State's total gross emissions. Total emissions from fossil fuel energy production and use slowed in 1998 and actually showed a decrease in 1999 as shown below in Figure O-3.

[3] NH Department of Environmental Services, *The New Hampshire 1993 Greenhouse Gas Inventory*, October 1997 http://www.des.state.nh.us/ard/ghgi/.

FIGURE O-3. New Hampshire 1990-1999 Greenhouse Gas Emissions for Fossil Fuel Energy Production and Use



Source: US Department of Energy, Energy Information Administration

Transportation accounts for the greatest use of fossil fuel energy in New Hampshire representing 38% and 42% of the total greenhouse gas emissions from energy use in 1990 and 1999, respectively (see Figure OV-3). Use of energy for power generation accounted for 34% of the state's greenhouse gas emissions for energy use in 1990, but only 26% in 1999. Commercial/industrial sources accounted for 13% and 16% of the emissions in 1990 and 1999, respectively. Finally, residential sources accounted for approximately 16% of the emissions in both in 1990 and 1999.

Many of the mitigation strategies recommended in this report result in direct cost savings from lower energy costs. Mitigation of climate change also helps to avoid significant costs from the adverse impacts of increased sea level, more severe weather, changes in natural resources, and health impacts. Mitigation strategies in *The Climate Change Challenge* enable New Hampshire to build a more efficient and sustainable economy. New Hampshire already has a high proportion of high tech jobs, which correlates to New Hampshire's high environmental quality of life. Companies facing a skilled labor shortage are locating in places where their employees want to live.[4] The health and vitality of New Hampshire's diverse natural environment of

[4] NetworkNH, *NH in the 21st Century, Competing in the New Economy,* December 1, 2000, see http://www.networknh.com/.

mountains, seacoast, forests and lakes is an integral part of its competitive economic advantage. The proposed mitigation strategies will support further high tech economic growth by

stimulating development of new energy and energy efficient technologies. Responding to climate change with the measures proposed in *The Climate Change Challenge* will help New Hampshire to compete in a global marketplace.

New Hampshire has participated in a cooperative effort to develop a regional climate change action plan under the auspices of the Conference of New England Governors and Eastern Canadian Premiers (NEG/ECP). The NEG/ECP Climate Change Action Plan calls for a proactive and aggressive approach to reducing greenhouse gases and sets specific goals and targets:

Short-term: *Reduce regional GHG emissions to 1990 emissions by 2010*

Mid-term: *Reduce regional GHG emissions by at least 10% below 1990 emissions by 2020, and establish an iterative five-year process, commencing in 2005, to adjust the goals if necessary and set future emissions reduction goals.*

Long-term: *Reduce regional GHG emissions sufficiently to eliminate any dangerous threat to the climate; current science suggests this will require reductions of 75-85% below current levels.*

The Climate Change Challenge provides the measures and actions necessary to meet the GHG emission reduction goals set forth by the NEG/ECP, as described below.

Power Generation Mitigation Strategies

- Implement the *New Hampshire Clean Power Strategy* (NHCPS) to reduce emissions of multiple pollutants from New Hampshire's electric power plants, including CO_2
- Develop environmental disclosure rules as part of deregulation of the retail electricity market and promote green power pricing
- Promote completion of two new gas-fired combined-cycle power plants in New Hampshire
- Promote photovoltaic energy systems wherever feasible
- Develop landfill gas to energy projects where feasible
- Expand the New Hampshire Wind Study Project
- Conduct geothermal energy feasibility study
- Maintain and, if possible, expand renewable energy resources in New Hampshire

Transportation Mitigation Strategies

- Pursue improvements to federal CAFE standards for passenger cars and light-duty trucks (which includes sport utility vehicles, SUVs)
- Aggressively pursue integrated transportation planning statewide to enhance alternative transportation and reduce overall vehicle miles traveled
- Promote and facilitate expansion and development of new passenger rail corridors
- Promote and expand the use of alternate fuel vehicles and fueling infrastructure
- Continue to support and facilitate Clean Cities Program to promote alternate fuel vehicles and infrastructure
- Promote alternative fuels for ground-service vehicles at Manchester Airport
- Continue to promote improved (cleaner) marine engines
- Continue enhanced vehicle inspection, maintenance and on-road diesel opacity testing, and develop a "clunker" car retirement program to reduce vehicle emissions per mile travelled
- Continue to pursue and facilitate funding for bikeways and walkways
- Promote telecommuting, alternative work schedules, carpooling and use of public transit to reduce vehicle miles traveled

Commercial/Industrial Mitigation Strategies

- Continue to promote and provide technical assistance to encourage energy efficiency and conservation through Energy Star Programs, Small and Cool initiative, and Industries of the Future
- Implement the DES Green Lodging initiative
- Revise commercial/industrial energy codes to incorporate more rigorous energy efficiency standards and use systems benefit charges to develop demand-side programs
- Integrate energy conservation into the New England Energy Pool's peak load response programs
- Promote the use of combined heat and power (cogeneration) particularly for distributed power generation
- Encourage use of less carbon intensive fuels in electricity generation and industrial applications
- Promote and facilitate the development and use of renewable energy resources

Residential Mitigation Strategies

- Continue to promote and provide technical assistance to encourage energy efficiency and conservation through EPA's Energy Star Homes programs, Governor's Office of Energy and Community Services' Weatherization Assistance Program, wood stove replacements, other initiatives
- Continue to promote and expand municipal recycling programs
- Revise residential energy codes to include more energy efficient standards and use system benefit charges to develop demand-side programs
- Pursue improvements in appliance and equipment energy efficiency standards
- Promote and facilitate financial incentives and/or assistance for incorporating energy efficiency and conservation in new construction
- Promote and facilitate development and use of renewable energy resources
- Facilitate market mechanisms to encourage purchase of renewable energy resources through retail electricity providers
- Promote conversion to natural gas by home owners for heat, hot water, and cooking

Because energy production and use is the overwhelming source of greenhouse gas emissions, strategies to curb emissions should be focused on energy efficiency in order to reduce energy production and use, and alternative and renewable energy sources. Actions to reduce greenhouse gas emissions in New Hampshire will focus on the major recommendations for the power generation, transportation, commericial/industrial and residential sectors. Also discussed in this report are strategies for mitigating emissions from consumer products and waste that contain and/or generate greenhouse gases. Lastly, this report highlights the role of government in educating citizens about climate change and providing incentives and removing barriers to actions that help reduce greenhouse gas emissions. Continued education and outreach initiatives, with specific focus on the cost-effectiveness and economic benefit of energy efficiency and reduction, are essential to the long-term effectiveness of these mitigation strategies.

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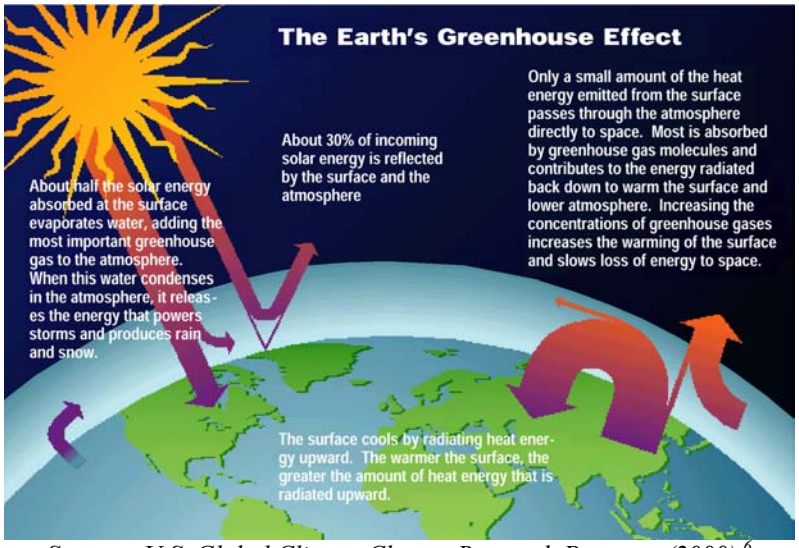
THE CLIMATE CHANGE CHALLENGE
Actions New Hampshire Can Take to Reduce Greenhouse Gas Emissions

1.0 CHARACTERIZATION OF THE PROBLEM

1.1 The Science of Climate Change

Complex interactions between the sun's energy, and the oceans, continents, atmosphere, and living things drive the earth's climate. As illustrated in Figure 1-1, some of the sun's energy absorbed by the earth is radiated back into the atmosphere as heat. Atmospheric gases such as water vapor, carbon dioxide, methane, halocarbons, ozone, and nitrous oxide (referred to as "greenhouse gases") absorb the heat radiated from the earth's surface. The atmosphere in turn radiates heat back to the earth further warming the surface. This so-called "greenhouse effect" maintains the earth's surface temperatures at levels that are conducive to life, as we know it. Increases in the concentration of greenhouse gases[5] in the atmosphere can intensify this effect, altering the earth's climate.

FIGURE 1-1. Graphic Depiction of the Greenhouse Effect



Source: U.S. Global Climate Change Research Program (2000) [6]

Changes in the earth's climate have occurred many times throughout the planet's history as a result of changing atmospheric conditions. The rapid increase in the atmospheric concentration of gases responsible for the greenhouse effect, and the ability of natural systems to adjust, is the subject of current climate change science.[6]

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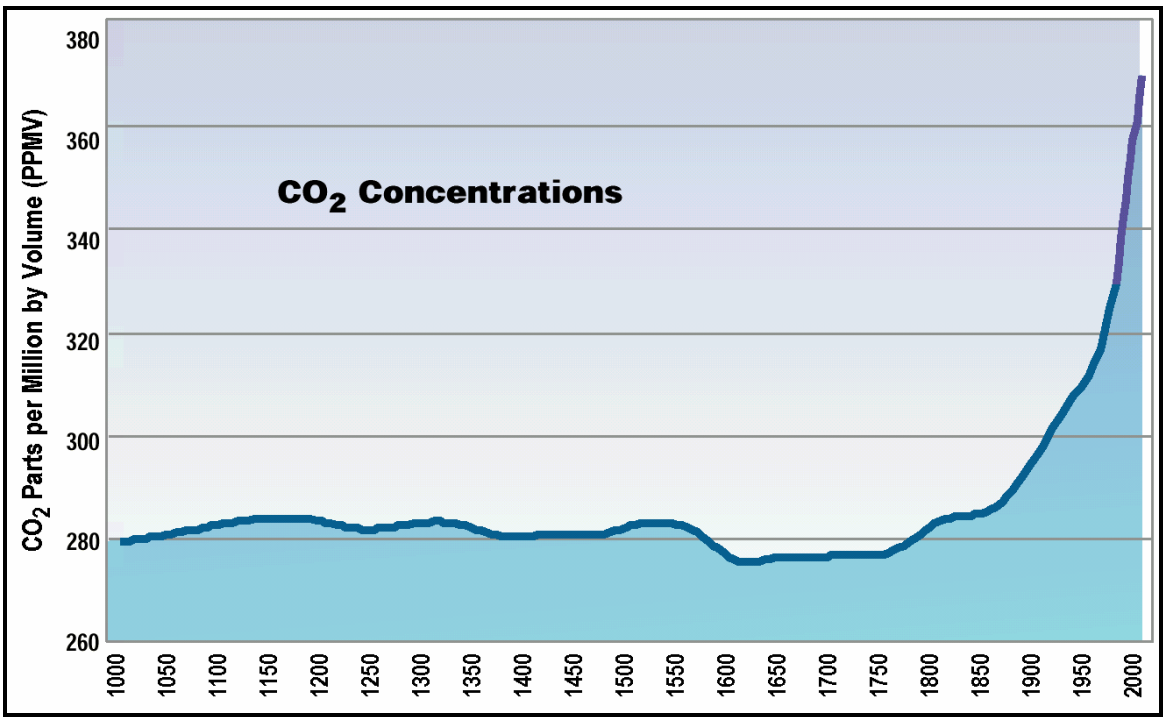
[5] Anthropogenic (man-made) greenhouse gases include carbon dioxide (CO_2), methane (CH_4), ozone (O_3), halocarbons, and nitrous oxide (N_2O), see **http://www.des.state.nh.us/ard/ghgi**.

[6] The discussion of climate change science throughout this chapter is drawn extensively from the U.S. Global Change Research Program, U.S. National Assessment Synthesis Team, 2000, *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change, s*ee **http://www.usgcrp.gov** .

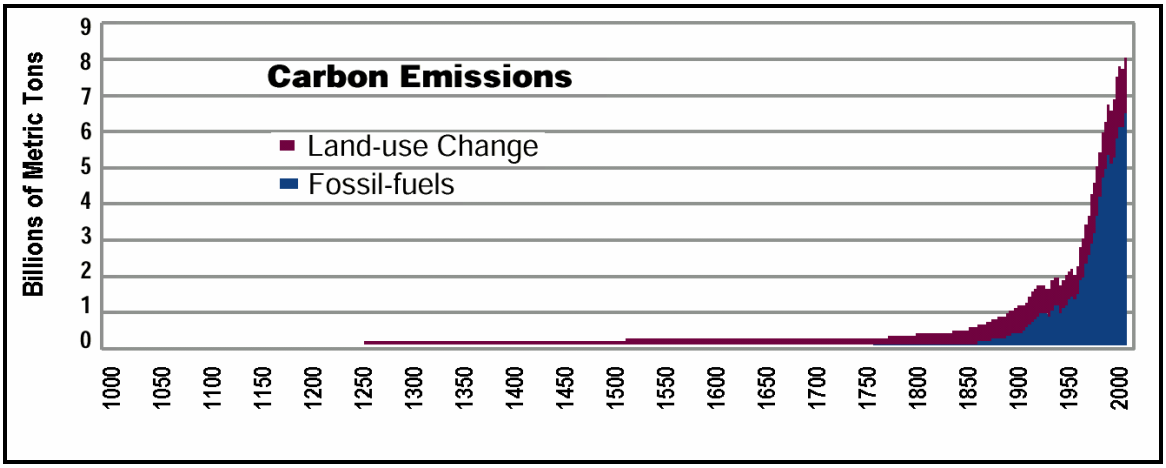
Human activities, in particular the combustion of fossil fuels, generate emissions of greenhouse gases. Other natural processes such as volcanic eruptions and decomposition, also generate greenhouse gas emissions. Since the late 1800's, the earth's atmosphere has experienced a 30% increase in CO_2 concentrations (see Figure 1-2). The current concentrations of CO_2 are significantly higher than those estimated at any time during the last 400,000 years. This increase is primarily due to burning fossil fuels and loss of forest and agricultural lands due to changes in land use from increased urbanization (See Figure 1-3).

FIGURE 1-2. Concentrations of Atmospheric CO_2 from Year 1000 to Present



Source: U.S. Global Change Research Program (2000) [6]

FIGURE 1-3. Emissions of Carbon Due to Fossil Fuels and Land Use Changes from Year 1000 to Present



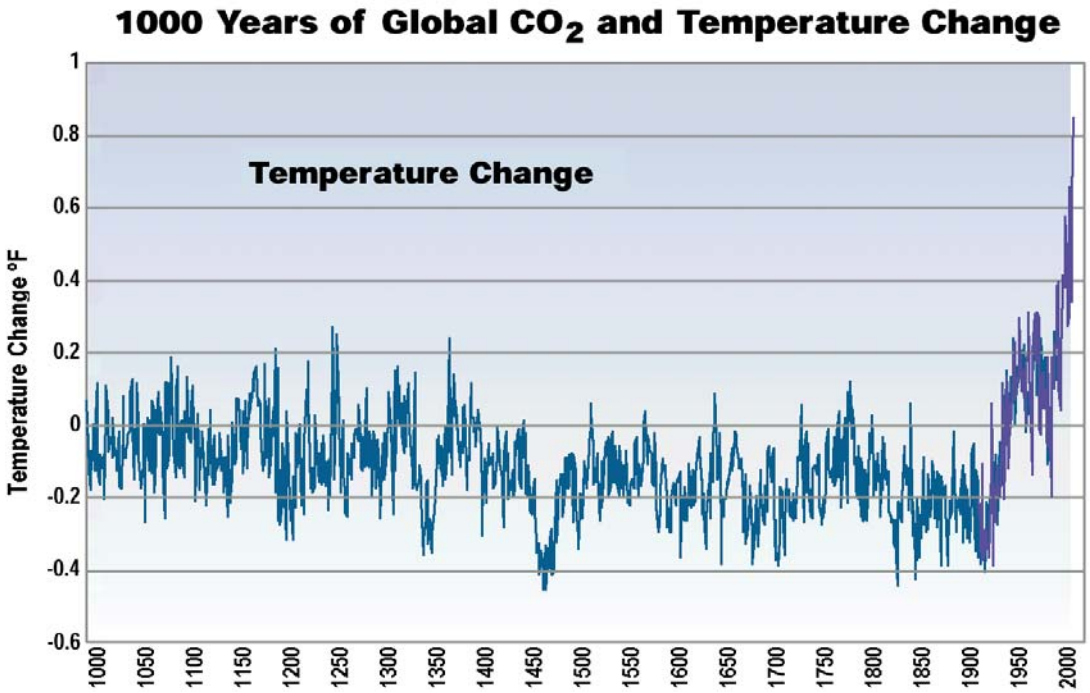
Source: U.S. Global Change Research Program (2000)

This trend is expected to continue based on current estimates of population growth and energy production and use. Some estimates by scientists indicate that atmospheric CO_2 concentrations will double, or triple, by 2100. These types of changes in greenhouse gas concentrations are monumental in the context of the short period of 200 years in geologic history. Adding more heat-trapping gases to the atmosphere is causing global temperatures to increase. There is now strong scientific consensus that global surface temperatures have increased an average of 1^{o} F over the 20^{th} century (see Figure 1-4). Recent analyses indicate that this is the largest increase in temperature in any century in the last 1,000 years.[7] Generally, higher latitudes have warmed more than equatorial regions, and about half of the increase in temperature has occurred since 1970. In the Northern Hemisphere, the data indicate that 1998 was the warmest year, and the 1990s were the warmest decade, of the 20^{th} century. [8]

[7] U.S. Global Change Research Program, U.S National Assessment Synthesis Team, 2000, *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change,* p. 13, see http://www.usgcrp.gov .

[8] IPCC, Working Group1 Third Assessment Report, *Climate Change 2001: The Scientific Basis,* January 2001, see http://www.ipcc.ch/pub/reports.htm.

FIGURE 1-4.



Source: U.S. Global Change Research Program (2000)

The Intergovernmental Panel on Climate Change (IPCC) is an international group of thousands of scientists, established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988, to assess scientific information about climate change relevant to international and national policy formulation. According to the third IPCC assessment report, released in January 2001, "there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."[9] Given current trends, climate models reviewed in the IPCC assessments project surface air temperatures to increase 2.5° F to 10.4° F by the year 2100. Although some scientific uncertainty remains as to the degree that the temperature will change and when these changes will occur, there is consensus among the overwhelming majority of scientists that concentrations of greenhouse gases are increasing at an unprecedented rate, and that changes in the earth's climate are now underway and will continue.

[9] IPCC, Working Group1 Third Assessment Report, *Climate Change 2001: The Scientific Basis,* January 2001. Summary for Policymakers, p.6, see http://www.ipcc.ch/pub/reports.htm.

1.2 Regional Effects of Climate Change

Climate change entails much more than global temperature rises. It is anticipated that increases in surface temperatures will result in a rise in the sea level, an increase in the number of extreme storm events, disruption of fresh water and food supplies, impacts to the vitality and health of forests and other natural areas, and potential impacts to human health.[10] Many scientists are concerned that these changes could have significant health and lifestyle consequences for humans. Impacts that are currently believed in large part to be the result of climate change are listed in Table 1-1.

TABLE 1-1. Potential Warning Signs of Climate Change

Temperature Increase[11]	• 1998 was the warmest year on record. • The six warmest years on record were all between 1990 and 1999. • U.S. Winter of 1999-2000 was the warmest on record.
Sea Level Rise[12]	• In the last century, average sea level has risen 4-8 inches.
Glaciers[13]	• Glaciers of the European Alps have lost 30-40% of their surface area and half their volume since 1850. • Glaciers on Mt. Kenya and Kilimanjaro have lost 60% of their area in last century. • Glaciers in central Asia have been retreating since 1950.
Arctic/Antarctic Ice Melt[14]	• Arctic sea ice area has declined 14% since 1978. • Arctic sea ice volume has declined by 40% in the last 20 years. • In 1998, Antarctica's Larsen ice shelves lost nearly 3,000 square kilometers of the total 24,000 square kilometers due to melting.
Cost[15]	• 14-fold increase in insured losses due to weather related incidents from 1960 to 1999. • Higher costs of road and municipal maintenance and operation due to increased storm intensity. • Flooding has cost the U.S. 31 billion dollars over the last 15 years.

[10] IPCC, Working Group2 Third Assessment Report, *Climate Change 2001: Impacts, Adaptation, and Vulnerability,* February 2001, see http://www.ipcc.ch/pub/reports.htm.

[11] NASA, 1999. Global temperature trends: 1998 global surface temperature smashes record. NASA Goodard Institute for Space Studies. 16 December 1998, see http://www.giss.nasa.gov/research/observe/surftemp/.

[12] IPCC Working Group1 Third Assessment Report, *Climate Change 2001: Impacts, Adaptation, and Vulnerability,* February 2001, see http://www.ipcc.ch/pub/reports.htm.

[13] Union of Concerned Scientists, Early Warning Signs of Global Warming: Glaciers Melting, see http://www.ucsusa.org/environment/gw_glaciers.html.

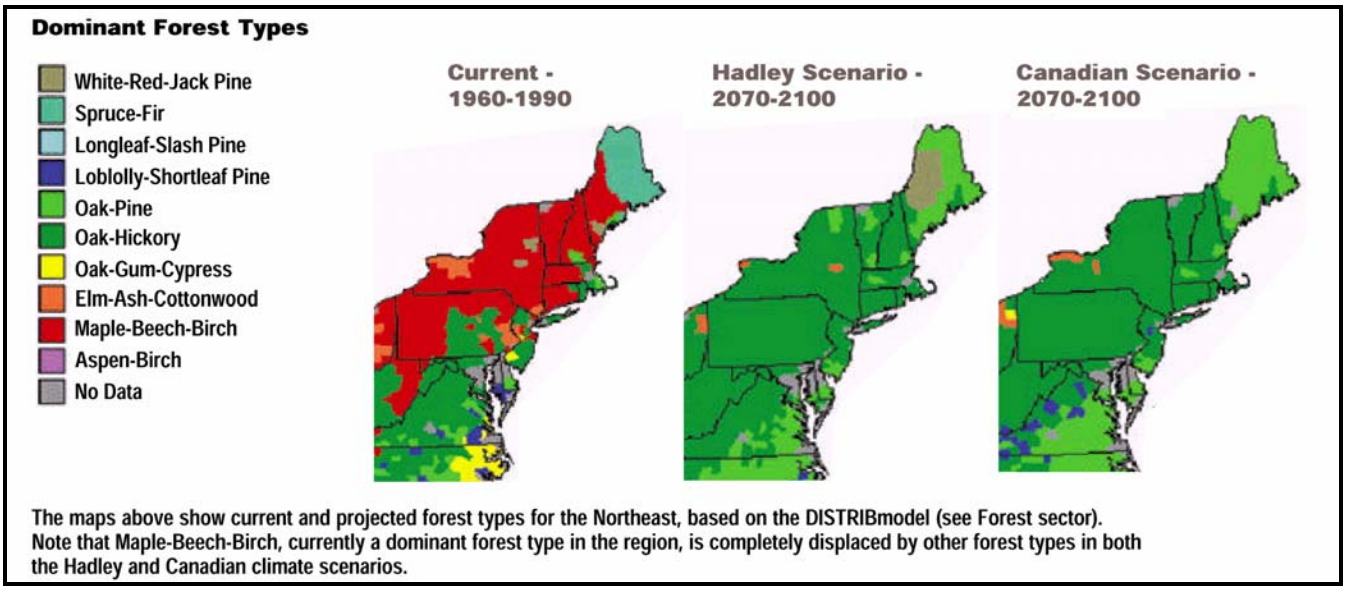
[14] Union of Concerned Scientists, Early Warning Signs of Global Warming: Arctic and Antarctic Warming, see http://www.ucsusa.org/environment/gw_arctic.html.

[15] US Insurance Industry Prospectives on Global Climate Change, February 2001, Lawrence Berkley National Library, see http://eetd.lbl.gov/insurance/cifram.html.

It is difficult to accurately assess the regional or local impacts of changes in the average global surface temperature. The nature and severity of changes are expected to vary by locale. Extreme weather events may occur more often. Some areas may experience greater precipitation some parts of the year and droughts during others. The intensity and volume of precipitation may increase resulting in much higher water runoff and erosion, causing soil quality to deteriorate, and less water will be retained as soil moisture.

Climate change impacts on the northeastern United States are likely to include aggravated stresses on urban areas, shifts in recreation, human health impacts and changes in species composition.[16] Climate change has the potential to add to the stress of our aging and deteriorating infrastructure in urban areas by further damaging utilities by increased sea levels and precipitation. Additional utility repair costs will stress already inadequate maintenance budgets in many northeastern cities and towns. Increased ground-level ozone concentrations as a result of increased temperatures would intensify existing air quality problems. Extended warmer seasons may enhance some summer-related recreational activities while curtailing those associated with colder temperatures and seasons. Increased outbreaks of infectious disease may occur, similar to the recent incidences of West Nile Virus and equine encephalitis in northeastern urban areas. Coastal areas may eventually see the lobster population migrate northward to cooler waters. In addition, the dominant forest type of maple-beech-birch may shift to more temperature-tolerant forests of oak-hickory (see Figure 1-5).

FIGURE 1-5. Projected Forest Types for the Northeast in 2070-2100 Under the Hadley and Canadian Climate Models



Source: *U.S. Global Change Research Program (2000)*

[16] U.S. Global change Research Program, U.S. National Assessment Synthesis Team, 2000 *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change,* Northeast Key Issues, see http://www.usgcrp.gov .

1.3 Climate Change Impacts on Quality of Life in New Hampshire

In general, warming is predicted to increase with latitude, and the most significant warming is predicted to occur in late autumn and winter.[17] Snow and ice cover is lost as the earth warms. Without the snow and ice cover, less solar radiation is reflected back into space. The additional bare ground will absorb more of the sun's radiation as heat, raising surface temperatures. As a result, areas such as New England may experience greater temperature increases than the global average.[18] In fact, as described in the *New England Regional Overview*, recent research indicates that temperatures in New Hampshire have increased 1.8^{o} F, nearly three times the regional average increase of 0.7^{o} F for northern New York and New England.[19] In addition, New Hampshire winter temperatures have increased 3.5^{o} F compared to an increase of summer temperatures of only 1.0^{o} F.

New Hampshire's quality of life is directly tied to its lakes, rivers, ocean shoreline, mountains, hardwood forests (which produce brilliant fall foliage), scenic towns, and other natural areas. New Hampshire's economy relies heavily on the tourism industry, as millions visit New Hampshire every year to enjoy the State's natural resources. An increase in average temperature in New Hampshire will impact the habitat characteristics of forests and water resources, and may also have a detrimental effect on public health. Examples of industries that may, over time, be adversely impacted by global climate change include tourism, forestry, maple syrup/sugar production, skiing, and game fishing.

A more detailed assessment of the local impacts of climate change to New Hampshire water and forest resources has been conducted. The report of the New Hampshire Local Impact Assessment Project will be released by the New Hampshire Department of Environmental Services by the spring of 2002. Much of the following discussion regarding impacts to the maple sugar industry, fall foliage, forests, health and sea level is taken from the *New England Regional Overview*.

1.3.1 Potential Impacts on the Skiing Industry

The following are potential impacts from climate change on the skiing industry:

- Potential mid-season rain and significantly more freeze-thaw cycles could result in more icy, granular conditions. Ski conditions in general may deteriorate.
- Mid-season rain would necessitate additional snow-making to restore conditions. Warming will be more pronounced during winter nighttime. Snow-making may be adversely

[17] Kattenberg A, Giorgi F, Grassi H, Meehl GA, Mitchell JFB, Stouffer RJ, Tokioka T, Weaver AJ, and Wigley TML (1995). (*Climate Models - Projections of Future Change*) (Eds. JT Houghton, LG Meira Filho, BA Calander, N Harris, A Kattenberg and K Maskell), Cambridge University Press, Cambridge, p285-357.

[18] Bloomfield J, Hamburg S, *Seasons of Change, Global Warming and New England's White Mountains*, Environmental Defense Fund Press, p7-8.

[19] U.S. Global Change Research Program, New England Regional Assessment Group, August 2001, *New England Regional Overview PREPARING FOR A CHANGING CLIMATE The Potential Consequences of Climate Variability and Change*.

affected. To cover one acre of ski trails with one foot of snow takes 150,000 to 180,000 gallons of water. Water supply will be an issue, as will be environmental impacts from such large water withdrawals.
- EPA estimates of national revenue ski losses are as high as $14 billion.
- Lost revenue translates to lost jobs. Approximately 17,000 New Hampshire residents are employed directly by the New Hampshire ski industry.

1.3.2 Potential Impacts on Fall Foliage and the Maple Sugar Industry

The following are potential impacts from climate change on fall foliage and the maple sugar industry:

- For the past 100 years, extreme events including increases of severe droughts, winter freeze-thaw cycles, and outbreaks of tree pests and pathogens have been associated with diebacks of several northern hardwood species.
- Several New Hampshire tree species may decline while others, if warming is severe enough, may perish. Northern hardwoods, and the beautiful fall colors they produce, may migrate north 100 to 300 miles. Southern trees may replace northern hardwood, spruce, and fir forests.
- Potential summer drought conditions would cause trees to drop their leaves prematurely.
- Sugar maples, a source of brilliant fall leaf colors, are extremely susceptible to mid-winter thaws and summer droughts and, therefore, may sicken, decline and disappear, or their geographic distribution may migrate north.
- Consequently, the maple syrup industry, an annual $2.7 million industry may be negatively affected or disappear altogether.
- Revenue from New Hampshire foliage visitors is approximately $292 million annually. On average foliage visitors spend 16 percent more than non-foliage visitors. Economic loss to the tourism industry may occur if the foliage visitation period is significantly reduced by tree species migration.

1.3.3 Potential Impacts on Cold Water Fishing

The following are potential impacts of climate change on cold water fishing:

- The temperatures of streams in New Hampshire may increase to levels exceeding tolerances for most cold water fish such as brook, brown, and rainbow trout.
- A recent EPA study for New England indicated that some states could potentially lose all habitat important for cold water fish. Estimates as high as a 50 percent loss were predicted for northern New Hampshire.
- Droughts accompanying climate change cause lower water levels and reduced stream flows leading to reduced food availability. Cold water fish may also be prevented from migrating to spawning grounds.
- Temperature is critical to reproduction in many cold water fish species. Even though some adult fish may tolerate higher stream temperatures, they may not reproduce as readily.

- Climate change may affect stream flow rates by increasing incidences of spring flooding and very low flow rates in late fall. Low water levels decrease availability of winter habitat, lessen reproduction, reduce food availability, as well as suffocate and desiccate fish eggs. Flooding scours stream bottoms of fish eggs.
- Warm water fish may have difficulty moving into vacated cold water fish habitat because they are unable to tolerate fast stream rates.
- Fishing in New England is big business. The American Sportfishing Association assessed the economic contribution of recreational fishing to New Hampshire at $320 million per year in direct expenditures by anglers, with a total of over $580 million and 7,710 jobs.[20]

1.3.4 Potential Impacts on Forests and Timber

The following are potential impacts from climate change on forests and timber industries:

- Certain trees and forests may flourish due to longer growing seasons, more abundant carbon dioxide, and wet summers.
- White pine and red oak, two very profitable timber species in New Hampshire, could increase in number. Other species may adapt. However, it is more likely on balance that climate change will bring adverse impacts to New Hampshire's forests.
- In general, ecological models predict that warmer temperatures and extreme weather events associated with climate change would move optimal conditions for the growth of northern hardwood forest species northwards by at least 100 to 300 miles by the end of the next century.
- Climate change of the magnitude predicted by some of the current climate models may both alter the species of trees and cause decline and widespread mortality in the forests of the White Mountains. Disturbances may increase (e.g., pest and pathogen outbreaks, flooding, and wind damage), and may kill a large number of trees and forests.
- Extreme events such as periods of winter thaw followed by intense cold, spring and summer drought, and summer heat stress, have been associated with diebacks and declines in several northern hardwood species in New England in the last 100 years.
- Sugar maple, ash, and yellow birch, which are all northern hardwoods, are sensitive to extreme weather events and may decline or even collapse.
- Foliage may dull and brilliant fall colors will fade as trees sicken, drop leaves early and other less colorful southern species move north.
- Forest product industries are the fourth largest employer in New Hampshire and third in terms of revenue. Gross revenues may be affected from changes to forest composition and health from climate change.

[20] American Sportfishing Association, *1996 Sport Fishing Participation and Economic Impact for New Hampshire*. See http://www.asafishing.org/content/statistics/economic/index.cfm?state=New+Hampshire.

1.3.5 Potential Impacts on Health

The following are potential impacts from climate change on health:

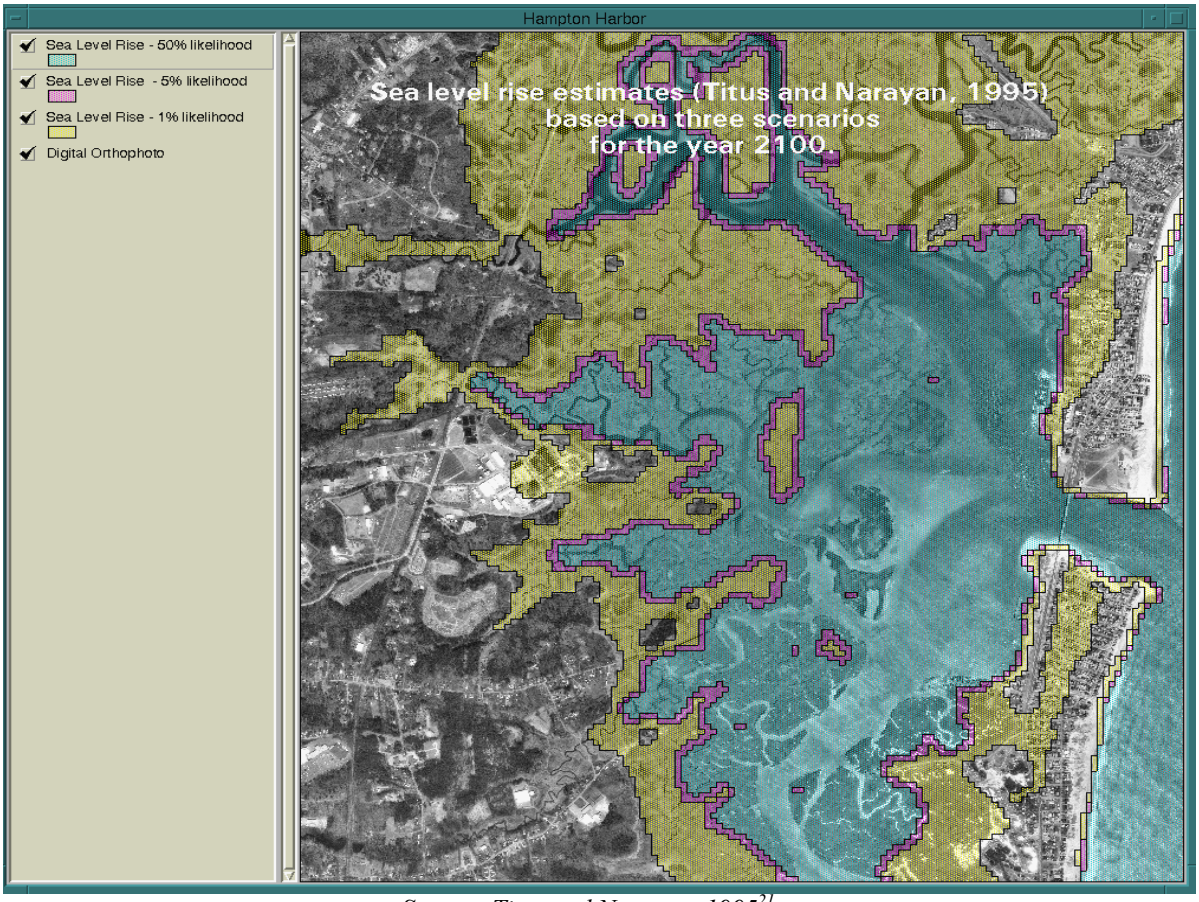
- Warmer temperatures may result in increased incidence of heat-related illness and death, particularly in the very young and very old.
- Increases in the frequency and intensity of extreme weather events (e.g., droughts, floods, summer and winter storms) may result in increases in death, injury, and decreased agricultural, animal, and fisheries productivity.
- Extreme weather patterns could modify regional ecosystems, altering patterns of plant diseases and pest infestations, and severely impact agriculture operations.
- Increased frequency and range of harmful algal blooms may result in more expansive red tide on New Hampshire's coastline.
- Climate change may produce new breeding sites for many pests and pathogens, resulting in higher incidence of infectious diseases, such as encephalitis.
- Diarrheal diseases caused by water dependent bacteria, viruses, and protozoa may increase due to increased water temperatures, rainfall, and flooding.
- Higher incidence of food poisonings may occur as a result of longer life spans and population explosions of bacteria, flies, and cockroaches, which contaminate food supplies.

1.3.6 Potential Impacts on the Seacoast

The following are potential impacts from climate change on New Hampshire's seacoast:

- Climate change may increase sea levels causing flooding of low-lying areas damaging roads, utilities, and personal property (see Figure 1-6).
- Rising sea levels may cause saltwater to migrate further inland and upstream shifting marine ecosystems and potentially affecting drinking water supplies.
- Increased flooding may result in overflows of waste water treatment facilities leading to poor water quality.
- Warm ocean waters may impact fisheries causing loss of the winter flounder population and shifts to warmer temperature tolerant species.

FIGURE 1-6. Three Levels of Sea Level Rise for Hampton Harbor; 1%, 5%, and 50% Likelihood



Source: Titus and Narayan, 1995[21]

1.4 Economic Impacts of Climate Change

The economic benefits from New Hampshire's natural resources are enormous. Recreation and tourism comprise the State's second largest industry. Potential effects from climate change on snow depth, fisheries, maple sugaring, and fall foliage would impact a multi-billion dollar industry. Each year, 48 million tourists visit New Hampshire and spend over $2.5 billion dollars. The number of visitors to New Hampshire's White Mountain National Forest exceeds that of Yellowstone and Yosemite National Parks combined. Tourism directly supports one out of every 12 jobs in New Hampshire.[22]

The potential economic impacts from climate change on our natural resources may also affect forest-based manufacturing, municipal and state infrastructure, spread of vector-borne disease,

[21] Titus, James G., and Vijay Narayan, *The Probability of Sea Level Rise,* EPA Document 230-R95-008, 1995.
[22] New Hampshire Department of Resources and Economic Development economic statistics.

and fisheries. The economic sectors threatened are large as shown by the summary statistics in Table 1-2.[23]

It is important to note that the data reported below is from readily available sources and that no original research or studies were conducted, nor was modeling performed to generate this economic data. These statistics are for informational purposes only to provide a general economic context to consider potential impacts from climate change. These data do not reflect estimates of the specific economic impacts that may occur as a result of climate change, or imply that potential economic impacts could be positive or negative.

TABLE 1-2. New Hampshire Economic Summary Statistics on Sectors Impacted by Climate Change

Sector	New Hampshire Annual Economic Statistics
Maple Syrup	• $2.7 million in commercial sales (1998 data from North East State Foresters Association)
Wildlife	• $66 million in direct hunting expenditures • $281 million in direct wildlife-watching expenditures • $132 million in indirect and induced effects from wildlife-watching • $91 million in wages and salaries (1996 data from US Fish & Wildlife Service)
Fishing	• $320 million in direct sport fishing expenditures • $260 million in indirect and induced effects (1996 data from American Sports Fishing Association)
Forestry	• $1.5 billion in forest-based manufacturing value of shipments • $51 million in sales of wood fuel • $6 million in sales of Christmas trees and wreaths • $4 million in timber tax • $509 million in revenues generated by forest-based recreation and activities (1998 data from North East State Foresters Association)
Flooding	• $7.59 million annual cost based on data from 1955-1975 and 1983-1999 (1999 data from National Center for Atmospheric Reasearch)
Skiing	• $209 million in direct and indirect spending during ski season • $58 million in state and local tax receipts due to direct and indirect spending • $87 million in improvements at NH ski areas during 1990-2000 (1999/2000 data from The Institute for New Hampshire Studies, Plymouth State College)

Note that these data are from readily available sources. No original research or studies were conducted, nor was modeling performed to generate new economic data.

[23] NH Local Impact Assessment Project, *Economic Statistics on LIAP Forestry and Water Issues,* Prepared by Gallagher, Callahan & Gartrell, May 2001.

2.0 NEW HAMPSHIRE GREENHOUSE GAS EMISSIONS

2.1 Basis for New Hampshire Greenhouse Gas Inventory

The *New Hampshire 1993 Greenhouse Gas Inventory*[24] focuses on anthropogenic emissions of the three primary greenhouses gases: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The inventory year of 1993 was chosen because, at the time of preparing the inventory, 1993 was the most recently available energy data from the Department of Energy, Energy Information Administration (DOE/EIA). Since energy production and use is the predominant source of greenhouse gas emissions in the United States, this data usually drives the timeliness of a greenhouse gas inventory. Note, however, that energy data from 1990 through 1999 (which is the most currently available energy data at the time of preparing this report) is presented in the following section to provide an update of the energy portion of the original inventory.

Carbon dioxide is by far the most prominent of the greenhouse gases in terms of total emissions. It is emitted naturally by living organisms, and is also a by-product of the combustion of carbon-based fuels, in particular fossil fuels used for transportation, heat, industry, and the production of electricity. At the same time, trees and other vegetation consume carbon dioxide (remove it from the atmosphere) as part of their life cycle, referred to as carbon sequestration. Carbon sequestration is estimated to offset anthropogenic greenhouse gas (GHG) emissions in New Hampshire by approximately 25 percent. Methane is generated primarily by natural gas distribution and anaerobic bacteria during the decomposition of organic matter. Sources include municipal solid waste landfills and enteric fermentation in ruminants (cattle, sheep and swine). Nitrous oxide (N_2O) is generated from the use of agricultural fertilizers and from the combustion of fossil and biomass fuels, primarily via the catalytic treatment of exhaust gases.[25] Other known GHGs included chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and ozone (O_3). Emissions of these other GHGs were not included in New Hampshire's Greenhouse Gas Inventory because guidance for estimating them, and their expected overall contribution to the inventory, is limited. However, mitigation of these gases is addressed by various proposed strategies described in later sections such as recycling, waste management, energy efficient appliances and better forest and agricultural practices.

Each greenhouse gas has a different potential to absorb heat. For a given concentration, methane can absorb 21 times more heat than carbon dioxide. This difference in the energy absorbing properties of a greenhouse gases is referred to as its global warming potential. The global warming potential of several greenhouse gases is listed in Table 2-1. Global warming potential is defined as the ratio of the global warming effect of a greenhouse gas to that of carbon dioxide. The global warming potential is used to express the total amount of greenhouse gases in terms of

[24] NH Department of Environmental Services, *The New Hampshire 1993 Greenhouse Gas Inventory*, October 1997, see http://www.des.state.nh.us/ard/ghgi/.
[25] Ibid.

tons of carbon dioxide equivalent (TCDE). For example, tons of methane emissions would be multiplied by 21 to express tons of carbon dioxide equivalent emissions.

TABLE 2-1. Global Warming Potential of Various Greenhouse Gases

Greenhouse Gas	Source	Global Warming Potential
Carbon Dioxide (CO2)	Fossil fuel combustion	1
Methane (CH_4)	Decomposition of organic matter and natural gas distribution	21
Nitrous Oxide (N_2O)	Fossil fuel and biomass combustion, fertilizer use	310
Chlorodifluoromethane (CF_2HC_l)	Residential air conditioners	1,700
Chloroflourocarbon-12 (CF_2C-12)	Automobile air conditioners	8,500
HFC-23 (a PFC)	Commercial refrigerant	11,700
Sulfur Hexafluoride (SF_6)	Electric insulator	23,900

Source: EPA Global Warming website[26]

2.2 Summary of New Hampshire Greenhouse Gas Emissions

Total gross anthropogenic greenhouse gas emissions for New Hampshire in 1993 were 17,777,610 tons of carbon dioxide equivalent (TCDE). Table 2-2 shows the gross anthropogenic greenhouse gas emissions in New Hampshire for 1993 by for CO_2, CH_4, and N_2O. However, carbon is also absorbed from the atmosphere by plants and animals (referred to as carbon sequestration). Net carbon dioxide emissions are described as gross TCDE emissions less the sequestered TCDE. When carbon sequestration from New Hampshire forests is factored into the carbon equation, New Hampshire's net GHG emissions are approximately 12,888,353 TCDE.

[26] EPA Global Warming website, see http://www.epa.gov/globalwarming/emissions/national/gwp.html.

TABLE 2-2. 1993 New Hampshire Emissions of Greenhouse Gases From Anthropogenic Sources, Percent by Emission Source

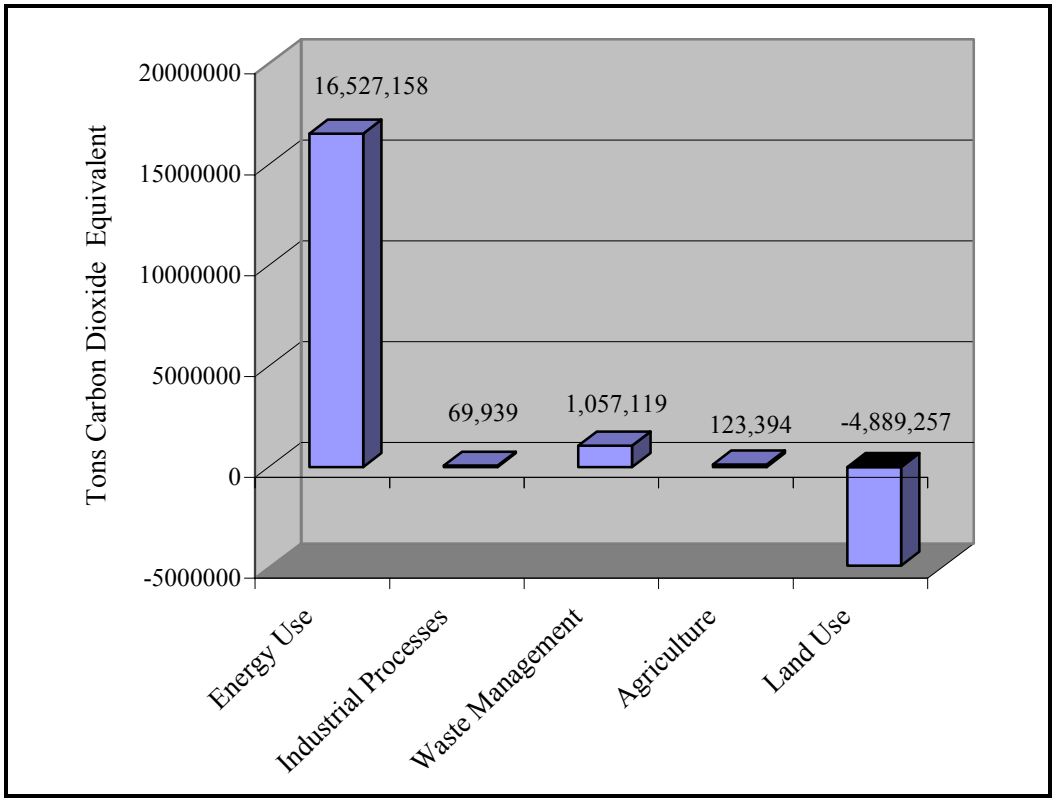
Greenhouse Gas (GHG)	Global Warming Potential[27]	Gross Emissions in Total Carbon Dioxide Equivalent (TCDE)	Emissions Source	Percent of Individual GHG Total
Carbon Dioxide (CO_2)	1.0	16,323,823	Fossil Fuel Combustion: Transportation Utilities Commercial/Industrial Residential Industrial Processes Agriculture	 37% 30% 17% 16% <1% <<1%
			Carbon Dioxide (CO_2) ***Percent of Total NH*** ***Gross GHG Emissions***	**92%**
Methane (CH_4)	24.5	1,255,827	Landfills/Waste Management Ruminants/Agriculture Fuel Consumption Natural Gas Distribution	84% 9% 4% 3%
			Methane (CH_4) ***Percent of Total NH*** ***Gross GHG Emissions***	**7%**
Nitrous Oxide (N_2O)	320.0	197,960	Transportation/fuel combustion Agriculture	97% 3%
			Nitrous Oxide (N_2O) ***Percent of Total NH*** ***Gross GHG Emissions***	**1%**

Source: New Hampshire 1993 Greenhouse Gas Inventory

[27] The global warming potential (GWP) for methane and nitrous oxide have been updated since the inventory was completed (see Table 2-1). The GWPs given in Table 2-2 were the best available numbers at the time New Hampshire's 1993 GHG Inventory was compiled. Table 2-1 provides the latest numbers accepted by the scientific community.

Emissions of greenhouse gases by sector are shown in Figure 2-1. Among these five sectors, energy production and use is the predominate sector, responsible for approximately 93 percent of total gross emissions. Land use, due to carbon sequestering (mostly from forest regeneration), acts to reduce total carbon dioxide emissions.

FIGURE 2-1. New Hampshire 1993 Greenhouse Gas Emissions

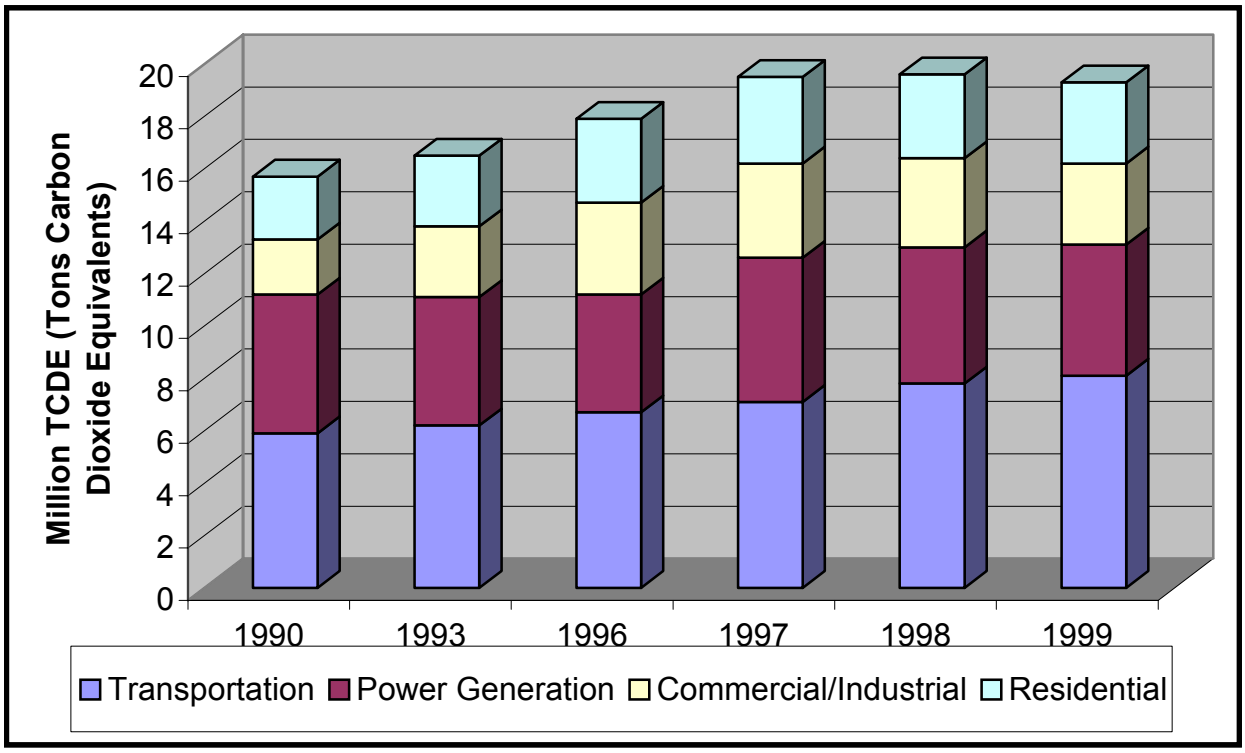


Source: New Hampshire 1993 Greenhouse Gas Inventory

Fossil fuel energy production and use for New Hampshire is available through 1999. Emissions of greenhouse gases from fossil fuel energy production and use have increased 20% from 1990 to 1999 (Figure 2-2).

During that time period, emissions from transportation increased 28%, emissions from power generation decreased 4%, emissions from commercial/industrial increased 34%, and emissions from residential increased 23%. The rate of increase of total emissions from fossil fuel energy production and use slowed in 1998 and actually show a decrease in 1999. Fossil fuel energy production and use in three out of the four energy production and use subsectors (i.e., power generation, commericial/industrial, residential) showed decreases in 1998 and 1999. These decreases are primarily due to reduced fuel consumption and, for the commercial sector, a shift in fuels to natural gas. In contrast to the other sectors, emissions from transportation increased approximately 10% between 1997 and 1998, and increased another 4% between 1998 and 1999.

FIGURE 2-2. New Hampshire 1990-1999 Greenhouse Gas Emissions for Fossil Fuel Energy Production and Use [28]

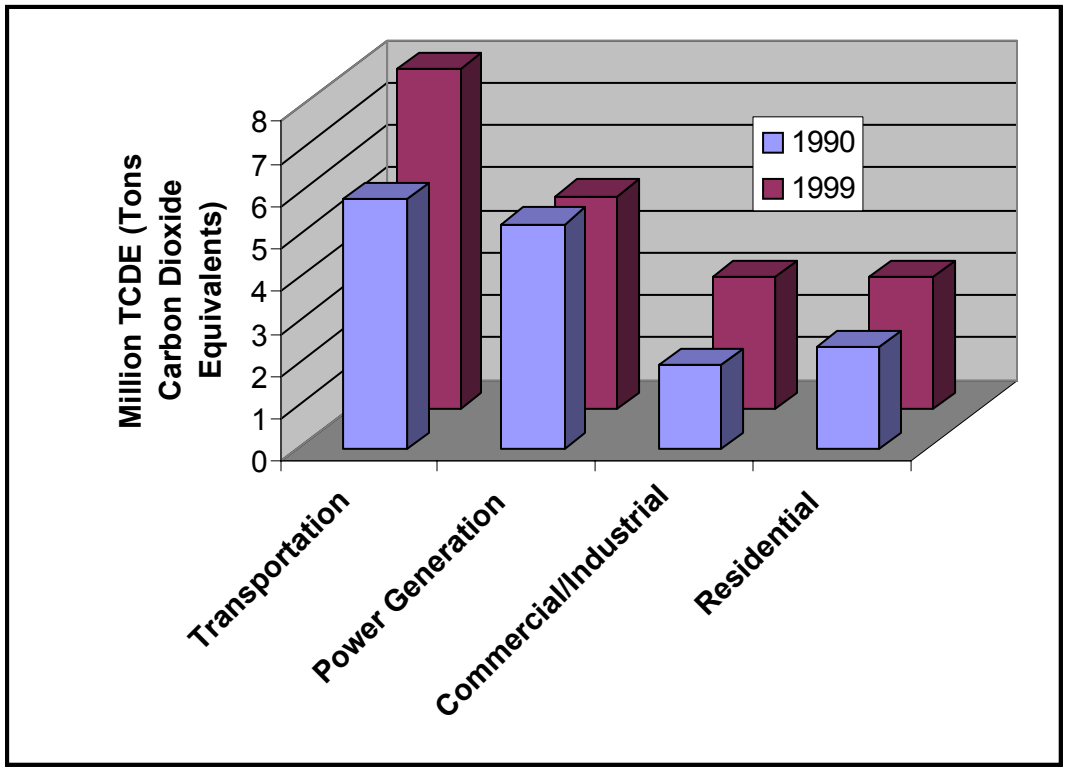


Source: US Department of Energy, Energy Information Administration

The transportation subsector represents the greatest proportion of fossil fuel energy production and use in New Hampshire accounting for 38% and 42% of the emissions in 1990 and 1999, respectively. Power generation had the next highest emissions, accounting for 34% of the emissions in 1990 but decreasing to 26% in 1999. Commercial/industrial accounted for 13% and 16% of the emissions in 1990 and 1999, respectively. Finally, the residential subsector accounted for approximately 16% of the emissions in both in 1990 and 1999.

[28] U.S. Department of Energy, Energy Information Administration, *State Energy Data Report 1999, see* http://www.eia.doe.gov/emeu/states/_states.html.

FIGURE 2-3. New Hampshire 1990 & 1999 Greenhouse Gas Emissions for Fossil Fuel Energy Production and Use [29]



Source: US Department of Energy, Energy Information Administration

2.3 Strategies for Reducing New Hampshire Greenhouse Gas Emissions

As is illustrated by New Hampshire's Greenhouse Gas Inventory, fossil fuel energy production and use are responsible for greater than 90% of the emissions generated in New Hampshire. This is generally the case in every state and nation. To reduce fossil fuel production and use, the focus of mitigation strategies must be on conserving energy, using fossils fuels more efficiently, and seeking alternatives to fossil fuels. Mitigation strategies are presented in order of relative contribution to emissions from fossil fuel production and use under transportation (Section 3), power generation (Section 4), commercial/industrial (Section 5), and residential sectors (Section 6). In addition to energy production and use, carbon storage and sequestration strategies (Section 7) will also be discussed because of their importance in mitigating emissions.

[29] U.S. Department of Energy, Energy Information Administration, *State Energy Data Report 1999, see* http://www.eia.doe.gov/emeu/states/_states.html.

3.0 TRANSPORTATION MITIGATION STRATEGIES

3.1 Overview

The transportation subsector (of the energy use sector) consists of on-highway (automobiles, light-duty trucks and vans, heavy-duty trucks and buses, and motorcycles) and off-highway (farm tractors and machinery, locomotives, construction equipment, aircraft, marine, and recreational) vehicles. This chapter focuses on mitigation strategies for on-highway vehicles because of their significant contribution to greenhouse gas emissions. New Hampshire gasoline (most of which is used in on-road vehicles) and diesel fuel use combined comprise approximately 95 percent of all New Hampshire transportation GHG emissions. New Hampshire transportation emissions comprise 37 percent of all gross New Hampshire GHG energy use emissions (see Chapter 2).

Carbon dioxide (CO_2) is the principle chemical byproduct of combustion of gasoline and other carbon-based transportation fuels, and CO_2 emissions are directly proportional to the quantity of fuel consumed. Burning a gallon of gasoline releases approximately 20 pounds of carbon dioxide in the air. Most on-highway vehicles are equipped with catalytic converters, which reduce emissions of carbon monoxide, volatile organic compounds, and nitrogen oxides from individual vehicles. However, CO_2 emissions are not controlled, and in fact most of the carbon monoxide in the exhaust is converted to CO_2 by the catalyst. The catalyst also contributes to the production of nitrous oxide (N_2O), another primary greenhouse gas. In addition, the production of refined fuels is energy-intensive, which also results in emissions of CO_2 and other greenhouse gases. Thus, fuel economy in vehicles is critical to reducing CO_2 emissions by using less fuel for the same amount of miles traveled. However, if overall vehicle miles traveled increase, savings from increased fuel efficiency can be lost. Thus, increasing fuel efficiency and reducing vehicle miles traveled must be concurrent strategies.

Alternative fuels such as natural gas, and technologies such as gasoline/electric hybrid vehicles are also important transportation strategies. Compressed natural gas cars have significantly lower emissions per mile traveled than gasoline since natural gas has lower emissions for an equivalent amount of energy burned. Hybrid cars provide significantly higher gas mileage and thus reduce GHG emissions through fuel efficiency.

3.2 Reduce Vehicle Miles Traveled (VMT)

3.2.1 Integrated Transportation Planning

In May 2000, New Hampshire Governor Jeanne Shaheen signed Executive Order 00-7, establishing the New Hampshire Integrated Transportation and Rail Advisory Council.[30] The purposes of the Council are:

- To identify and address national, regional, statewide, and local issues that impact highway, rail, and air transportation in New Hampshire with the goal of creating a

[30] Annoucement and Advisory Council Members, see http://www.state.nh.us/governor/media/051700transportation.html.

balanced and integrated transportation system.

- To provide a forum for effective participation in rail, highway, and air transportation planning processes by state agencies, businesses, and individuals involved in the intermodal transportation of people and goods.
- To engage with the state in the development of a long-range strategic transportation plan that integrates highway, rail, and air transportation.
- To assist the state in optimizing use of transportation infrastructure in the context of New Hampshire's economy, environment, and heritage.

The Council provides annual reports on its activities to the Governor. Commissioned members include representatives from local and intercity bus industries, regional planning offices, the New Hampshire Railroad Revitalization Association,[31] environmental organizations, transit authorities, railroad authorities, and airport management. Through integrated transportation planning, New Hampshire is providing a forum for various interests to have input on transportation planning.

New Hampshire should aggressively pursue this avenue as a way to enhance alternative transportation to help minimize and eventually reduce overall vehicle VMT in the State, which over time will help reduce greenhouse gas emissions.

3.2.2 NH Carpooling Programs and Use of Public Transit

The New Hampshire Department of Transportation (NHDOT) has implemented a statewide "RideShare" initiative,[32] an information service to promote carpooling and use of public transit. NHDOT works with employers, motorists, and groups such as local Transportation Management Associations (TMAs), to encourage, and provide logistical support for, carpooling and the use of public transit. NHDOT can continue to expand its services under this program to reduce VMT by expanding RideShare staff and through greater outreach efforts (e.g., public service announcements, widely distributed leaflets/pamphlets, press coverage, etc.).

The NHDOT has constructed a series of Park and Ride facilities around New Hampshire, which provide centralized long and short term parking for commuters and others looking to carpool or use public transit. One such facility, located in Portsmouth, New Hampshire, which provided 500 parking spaces, was at capacity within a month of final construction. New Hampshire can enhance the Park and Ride service by expanding those that are at or near capacity, locating additional facilities near public transit outlets (such as proposed rail stations), and through greater outreach efforts.

New Hampshire could initiate a public service educational campaign to inform consumers about the attractive features and availability of public transit, including public service announcements with messages about cost, convenience, and environmental benefit, signage for transit outlet locations, and distribution of transit service maps and informational brochures describing New

[31] New Hampshire Railroad Revitalization Association, see http://trainweb.org/nhrra/.
[32] NH Department of Transportation Ride Share Program, see http://webster.state.nh.us/dot/rideshare/index.html.

Hampshire's existing transit system and proposed enhancements.

3.2.3 New Hampshire Passenger Rail Revitalization

Amtrak recently re-established a rail connection between Portland, Maine and Boston, Massachusetts, which will include three stations in New Hampshire, which is slated to be in service in the fall of 2001. This service will provide four trains per day with stations at Dover, Exeter, and Durham New Hampshire.

The Metropolitan Boston Transit Authority (MBTA) is a Massachusetts-based rail system providing commuter service in most of eastern Massachusetts. A federally funded project to expand MTBA service into southern New Hampshire, spearheaded by the Nashua Regional Planning Commission and New Hampshire Department of Transportation, is currently in the design phase. Service to two locations in Nashua, New Hampshire is targeted for 2004.

In October 2000, the U.S. Department of Transportation designated a new high-speed rail corridor in Northern New England with a hub at Boston that will ultimately serve destinations in Maine, New Hampshire, Vermont, and Montreal, Canada.[33] A high-speed rail corridor designation provides a catalyst for State, local and public interest in corridor development. The designation provides $200,000 for a preliminary study of corridor potential and capital/operating costs.

Legislation introduced in the New Hampshire House during the 2000 state legislative session (HB 1378) established an ongoing task force (members include legislators, planners, state agencies) to study the re-establishment of passenger rail service from Newbury, Massachusetts to New Hampshire's Seacoast area. HB 1409, also passed during the 2000 state legislative session, established a legislative committee to study the potential of extending rail service to from Lawrence, MA to central and western New Hampshire.

In addition, New Hampshire Department of Transportation is committing to a comprehensive rail study on an adjunct to the Interstate-93 (I-93) widening project.[34] Including mass transit options in the I-93 corridor will help improve congestion problems and air quality. Mass transit would also help to offset what is sometimes referred to as "induced travel" – the increased use of an expanded/upgraded roadway due to the inherent increased capacity the expanded roadway now provides. The New Hampshire Rail Rivitalization Association (NHRRA) actively tracks many of these initiatives and is a useful resource.[35]

3.2.4 Expand and Promote Bikeways and Walkways

The New Hampshire Department of Transportation (NHDOT) has constructed bikeways and walkways in New Hampshire in association with transportation projects. In addition, NHDOT has helped New Hampshire communities acquire federal funding for bikeways and walkways. Encouraging bikeways and walkways helps to reduce reliance on the use of the automobile, and

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[33] For further information, see http://www.dot.gov/affairs/fra2000.htm.
[34] For further information on *Rail Alternatives Evaluation Report* and the *I-93 Corridor Study*, see http://www.state.nh.us/dot/10418c/raildoc.htm and http://www.state.nh.us/dot/10418c/default.htm.
[35] New Hampshire Railroad Revitalization Association, see http://trainweb.org/nhrra/.

thereby helps to reduce greenhouse gas emissions from transportation. NHDOT should continue to encourage, and facilitate funding for, these projects.[36]

3.2.5 Promote Telecommuting and Alternative Work Schedules

Telecommuting involves home-based work, or working from a nearby telecommute center to decrease commute travel. This option is enhanced by advancements in electronic communications (i.e., internet, email, voicemail). Similarly, compressed work schedules (such as working four ten-hour days a week versus five eight-hour days) can eliminate some commuter travel. Proximate commuting involves employee job swapping of relatively interchangeable positions at companies with multiple branches (e.g., retail clerks, chain restaurant staff) in order to shorten the commute distance of employees. Private industry, non-profit institutions and state government should adopt these programs, where appropriate, with the State serving as a model in the design and promotion of telecommuting and compressed work schedules for its approximately 10,000 employees.

3.2.6 Promote Pricing Measures which Reduce VMT

Market-based parking charges are access fees for parking at offices, malls and apartment buildings. These charges can eliminate a large subsidy borne by non-drivers financially supporting the infrastructure (e.g., parking lots, plowing, etc.) necessary for the automobile.

Cash-out parking provides employees with the option of receiving cash instead of driving to work and using employer-provided "free" parking. Experience with cash-out parking has proven that employers will save in parking costs by reduced demand.

3.2.7 State Government Transportation Demand Management Plan

A consortium of New Hampshire state agencies, including the Department of Transportation, the Governor's Office of Energy and Community Services (Energy Office), the Office of State Planning, and the New Hampshire Department of Environmental Services (DES), should establish a comprehensive Transportation Demand Management (TDM) plan for state agencies, with clear goals for reducing single occupancy vehicles (SOV) driven by state employees either on the job or to and from work. Reducing single occupancy vehicles would reduce total vehicle miles traveled and, thus greenhouse gas emissions from mobile sources of transportation. In developing this comprehensive plan, state government should explore programs that give state employees a choice of compensation for reducing SOV driving, including transit passes, van pool benefits and cash for personal transportation choices, including cycling. This could be a phased-in program, with expanded options as they become available.

[36] For an example of a bicycle coalition for promoting bikeways, see http://www.massbike.org/.

3.2.8 Expand and Promote New Hampshire Rideshare Program for State Employees

New Hampshire has initiated a statewide "RideShare" initiative, and the number of "Park and Ride" facilities has increased throughout the state for persons using public transit and carpooling/vanpooling.[37] The State should promote this program among its employees. As one of the biggest employers in the state, New Hampshire has a responsibility to promote this program from within. Carpooling reduces total vehicle miles traveled and thus total greenhouse gas emissions from mobile sources.

3.3 Reduce Emissions Per Vehicle Mile Traveled (VMT)

3.3.1 Promote Raising the Federal CAFE Standard

According to U.S. Environmental Protection Agency's Light-Duty Automotive Technology and Fuel Economy Trends[38] report (through 1999), overall fuel economy of light-duty vehicles[39] (which includes the popular sport utility vehicles and min-vans) is declining, truck market share is increasing, and fuel economy is being sacrificed for vehicle weight and performance. The average fuel economy for all model year 1999 light vehicles is 23.8 miles per gallon (MPG), the lowest value since 1980, and a full 2.1 MPG less than the peak value of 25.9 MPG achieved in 1987 and 1988. The primary reason for the decline is the increasing market share of light-duty trucks (which includes SUVs), which have lower average fuel economy than cars.

The federal Corporate Average Fuel Economy (CAFE) standard, which has been frozen at 27.5 miles per gallon for passenger cars and 20.5 mpg for light-duty trucks since 1985, is a significant trigger for overall improvement in average fuel economy. Improvements in corporate vehicle fleet mileage will, over time, significantly reduce GHG emissions per VMT. Because light-duty vehicles account for approximately 40% of net GHG emissions in New Hampshire,[40] improvement in the CAFE standard for light-duty trucks represents a significant GHG reduction strategy.

Federal law preempts states from setting their own CAFE standards. New Hampshire should work with other states, its Congressional delegation, environmental groups, and others to pursue improvements to the federal CAFE standards, with a target of increasing the standard to 37.5 MPG for passenger cars and 30.0 MPG for light-duty trucks by 2010. New Hampshire should also design public outreach campaigns to inform consumers about the environmental impacts of their vehicle choices.[41]

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[37] NH Department of Transportation Ride Share Program, see http://webster.state.nh.us/dot/rideshare/index.html.
[38] Office of Transportation and Air Quality Light-Duty Automotive Technology and Fuel Economy Trends, see www.epa.gov/otaq/fetrends.htm.
[39] Light-duty vehicles includes passenger cars and light-duty trucks (sport utility vehicles, minivans, and pickup trucks with less than 8,500 pounds gross vehicle weight ratings).
[40] See New Hampshire 1993 Greenhouse Gas Inventory, Table A-I.1a.
[41] For information on environmental ratings of vehicles, see http://www.fueleconomy.gov/ , http://www.greenercars.com/indexplus.html, and http://www.epa.gov/orcdizux/cert/feguide/fegsear.htm.

3.3.2 New Hampshire's Enhanced Safety Inspection Program

Beginning in 1999, New Hampshire adopted an Enhanced Safety Inspection Program, which focuses on visual inspections of key emissions control components on vehicles registered in New Hampshire. The Enhanced Safety Inspection Program, implemented by New Hampshire's Department of Safety (DOS), is expected to result in improved overall maintenance of New Hampshire's vehicle fleet. Although this program is not expected to yield significant reductions in greenhouse gas emissions (the focus of the program is reductions in mobile source emissions), enhanced maintenance will yield some benefit via improved fuel economy in some vehicles.

3.3.3 On-Road Diesel Opacity Testing Program

Also beginning in 1999, New Hampshire implemented an on-road diesel opacity test program. Under this program, "smoking" diesel trucks (vehicles with highly visible emissions) are pulled over by Department of Safety personnel, or in conjunction with truck weigh station activities, and their exhaust opacity measured to verify compliance with requirements for the model year of the vehicle.[42] For vehicles that fail opacity testing, repairs/adjustments to the engine must be made to reduce high opacity emissions. Although this program is not expected to yield significant reductions in greenhouse gas emissions, unburned fuel contributes to high opacity emissions from diesel vehicles, so it is expected that repairs will result in improved fuel economy.

3.3.4 On-Board Diagnostics (OBD) Inspections

As part of new vehicle certifications for model years 1996 and newer, new vehicles are required to be equipped with on-board diagnostics (OBD) systems. These systems allow for a comprehensive inspection of the emissions control system (and some performance related issues) by plugging a scan tool into a vehicle's universal OBD port. While the systems have been required since 1996, U.S. Environmental Protection Agency did not originally require OBD inspections as part of enhanced vehicle Inspection and Maintenance (I/M) programs until January 2001. The U.S. Environmental Protection Agency has delayed that implementation date now until January 2002.

New Hampshire is moving forward with incorporating OBD inspections as part of its Enhanced Safety Inspection program, planning for mandatory OBD inspections and repairs consistent with U.S. Environmental Protection Agency's OBD schedule (at this time scheduled for January 2002).[43]

OBD inspections provide an in-depth review of a vehicle's operating status. Repairs made on failing vehicles are expected to result in improved vehicle mileage and lower GHG emissions.

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[42] NH Department of Safety "Special Projects and Emissions Program", see http://webster.state.nh.us/safety/9799mv.html.

[43] NH DES Environmental Fact Sheet, *On-Board Diagnostics A New Generation of Motor Vehicles,* see http://www.des.state.nh.us/factsheets/ard/ard-30.htm.

3.3.5 New Hampshire Green Car Labeling Program

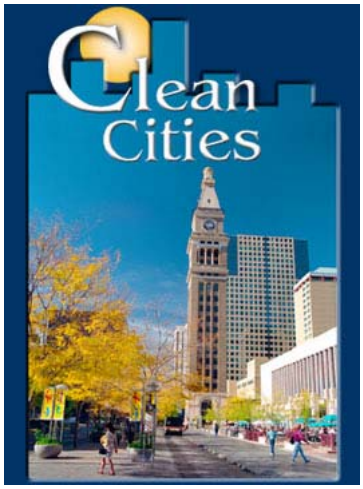
DES is currently working with the New Hampshire Auto Dealers Association to establish a Green Car Labeling Program. This program will improve customer awareness of clean vehicles by providing special labels for cars and trucks that are certified to the Low Emission Vehicle (LEV) standard[44] and achieve 30 miles per gallon or better. The promotion of higher mileage vehicles will help make consumers aware of the clean car options that are available to them.

3.3.6 Clunker Car Retirement

Another strategy New Hampshire can consider, as a way to reduce emissions per VMT is a Clunker Car Retirement program to get older, lower mileage vehicles off the road. Incentives for motorists to retire old vehicles could include payment for registered vehicles to be retired, rebates for purchasing a new car meeting certain criteria (i.e., minimum fuel economy, maximum emission standards), and rebates for energy efficient appliances. Funding for incentives could be provided through registration surcharges for vehicles with poor fuel economy and/or emission standards (which could also provide another incentive for consumers to purchase higher mileage, lower emitting vehicles), federal transportation grants, and safety/emissions inspection surcharges.

3.4 Alternative Technologies and Fuels

3.4.1 Clean Cities Program



Clean Cities[45] is a program sponsored by the federal Department of Energy that is designed to encourage the use of alternative fuel vehicles throughout the nation. Alternative fuels reduce greenhouse gas emissions (and other major pollutants) from transportation and enhance energy security by promoting the use of domestic fuels.

The Clean Cities program fosters public-private partnerships to bring alternative fuel vehicles (AFVs) to municipal transit fleets, public schools, private fleets, and other "niche" applications. Membership in the Clean Cities programs enables participants to apply for DOE grant funds for AFV projects.

Over the last three years, New Hampshire has established a fleet of alternative fuel vehicles and refueling stations for use by state agencies. There are also several businesses and utilities that use alternative fuels for transportation, primarily compressed natural gas and propane. However, overall market penetration has been limited. There are currently only 209 AFVs in the State and there are few locations (33) within the state for refueling AFVs.

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[44] LEV refers to "Low Emission Vehicle," a certification standard established under the California LEV program. This certification sets standards for NOx, VOCs, and CO, but has no CO_2 standard. The climate change benefit of the Green Car Labeling Program lay in the promotion of higher mileage vehicles.

[45] For more information on Clean Cities, see http://www.ccities.doe.gov/.

For these reasons, the Energy Office and DES have launched a joint effort to create a statewide Granite State Clean Cities Coalition. The goal of the coalition is to gain membership in the national Clean Cities program, and to expand efforts here to reach "heavy duty" fleets and create a network of alternative fuel refueling stations around the state. By 2006, the program hopes to double the number of AFVs to 450 and the number of refueling locations to 64.

Since February of 2000, the Energy Office and DES have sponsored a series of meetings and events throughout the state to bring together a coalition of stakeholders (city officials, private fleet operators, fuel providers, and utilities) committed to promoting AFVs in New Hampshire. Initial efforts have focused on urban areas and transit fleets such as the Wildcat bus system at the University of New Hampshire in Durham. The coalition has drafted a Clean Cities application that was submitted to DOE in August 2001. The coalition is hoping for full designation by January 2001.

New Hampshire should continue to support the development of the Clean Cities program and encourage new stakeholders to join the coalition.

3.4.2 Promote and Expand Use of Electric Vehicles

New Hampshire currently owns and operates 13 electric vehicles.[46] Four of these vehicles were purchased with funds from a Congestion Mitigation and Air Quality (CMAQ) grant for an Alternative Fuels Vehicle Project. Another nine electric vehicles (Chevy S-10 pickups) were received by the State as part of a settlement between U.S. Environmental Protection Agency and General Motors Corporation, and were given to various state agencies.

Several of the electric vehicles, which are clearly marked as electric vehicles, were on display for this event. New Hampshire should continue to pursue funding for, and purchase of, electric vehicles, and continue to promote their use in appropriate applications.[47] Further information on New Hampshire's alternative fuel vehicle program can be found at the DES Air Resources Division mobile sources website.[48]

3.4.3 Promote and Expand Use of Natural Gas Powered Vehicles

A part of the Alternative Fuels Vehicle Project (funded by CMAQ monies), New Hampshire installed a natural gas refueling station and subsidized the purchase of several natural gas powered vehicles for the state's fleet.[49] Ten dedicated natural gas vehicles have been purchased by state agencies thus far, with subsidy money available for another eight vehicles.

New Hampshire should continue to promote the use of natural gas vehicles in the State's fleet

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[46] For further information on alternative fuels in transportation, see http://www.afdc.nrel.gov/ and http://afdc3.nrel.gov/documents/altfuelnews/.
[47] For information on alternatively fueled vehicles, see http://homepages.ihug.co.nz/~don_s/alternatefuelslpg.htm.
[48] NHDES Air Resources Division Mobile Sources, see http://www.des.state.nh.us/ard/mobilesources/.
[49] For further information on alternative fuels in transportation, see http://www.afdc.nrel.gov/ and http://afdc3.nrel.gov/documents/altfuelnews/.

and in the private sector, and promote the establishment of commercial refueling facilities.[50]

3.4.4 Promote and Expand the Use of Hybrid Vehicles

DES owns and operates two hybrid vehicles, which combine a gasoline engine and electric motor to power the vehicle. A sophisticated on-board computer regulates the operation of each to balance a more efficient operation of the vehicle (i.e., high miles per gallon). Unlike electric vehicles, hybrid vehicles never need an outside source of electricity because recharging of the battery pack is accomplished using the operation of the gasoline engine and recapturing energy normally lost through braking (known as regenerative braking). The range of hybrid vehicles is essentially unlimited because they use only gasoline as a fuel, which is readily available anywhere. Both DES hybrid vehicles are clearly marked as being hybrids, and are used for general transportation and for outreach activities. Hybrid vehicles are available commercially at prices comparable to gasoline-powered cars.[51] Tax credits may become available for fuel-efficient vehicles as called for in President Bush's National Energy Policy.

New Hampshire should promote the purchase and use of hybrid vehicles within the State's fleet, business fleets, and by private citizens.

3.4.5 Promote Alternative Fuels at Manchester Airport

New Hampshire's Manchester Airport is one of the nations fastest growing airports. Long-term work with the Department of Transportation is on-going to reduce congestion around the airport and work toward reducing single occupancy vehicles in and around airport. Efforts to complete a mass transit loop between Manchester Airport and the greater Boston area should also be pursued.

Airport management, working cooperatively with DES and the Energy Office, is considering such improvements as electrification of ground service equipment and some parking lot shuttle buses to reduce air emissions. In addition, the feasibility of providing electricity to planes at airport gates to provide power for lights, climate control, and cleaning is also being examined (such that the plane's engines can be shut down while at the gate).

DES will continue to work with officials at Manchester Airport to identify and pursue ways to enhance operations and reduce overall greenhouse gas emissions. Options include electrification of ground service equipment, plane gate locations, and parking lot shuttle buses. In addition, through the Clean Cities stakeholder meetings, several small airport shuttle services have expressed an interest in locating a compressed natural gas refueling station near the airport. New Hampshire should continue to work with Manchester Airport officials to support the establishment of a commercial CNG refueling station at the airport.

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[50] For additional information on vehicles powered by natural gas, see http://naturalfuels.com/vehicles.htm.
[51] For additional links concerning hybrid vehicles, see http://www.navc.org/link1.html.

3.4.6 Promote Improved Marine Engines

In February 2000, DES initiated a proactive strategy to encourage the early introduction of low pollution 2-cycle (direct injection) and 4-cycle outboard marine engines. The U.S. Environmental Protection Agency's 1996 regulation required the phase-in of these engines between 1998 and 2006. The U.S. Environmental Protection Agency estimates that the cleaner outboard engines reduce hydrocarbon emissions from pleasure craft by 75%. The engines burn 35-50% less gasoline and use up to 50% less lubricating oil.

The New Hampshire program relies on a Memorandum of Agreement between the states' marine engine dealers (represented by the New Hampshire Marine Trades Association) and DES. Dealers signing on to the Memorandum of Agreement agree to voluntary goals for the sales of the new low pollution engines. These goals begin at 50% in 2000 and increase to more than 90% in 2003 and beyond. Dealers will report their sales to the Association's counsel, who will then report aggregate results to DES.

To date, thirty three New Hampshire marine dealers and retailers (out of an estimated 100) have signed the agreement. The results for the 2000 season have been tabulated and the participating dealers not only met the 50% goal, but surpassed it. For all the outboard engines sold by the dealers, 65% were cleaner low pollution engines.

In April 2001, DES and the New Hampshire Marine Trades Association were recognized for this effort with an EPA New England's Environmental Merit Award for "outstanding efforts in preserving New England's environment". New Hampshire should continue to promote this effort.

4.0 POWER GENERATION STRATEGIES

4.1 Overview

As is illustrated by New Hampshire's Greenhouse Gas Inventory (see Chapter 2), fossil fuel energy production and use are responsible for greater than 90% of the emissions generated in New Hampshire. To reduce fossil fuel production and use, the focus of mitigation strategies must be on conserving energy, using fossils fuels more efficiently, and seeking alternatives to fossil fuels. Reducing energy consumption or switching to less carbon intensive fuels (i.e., oil to gas) or renewable energy resources reduces greenhouse gas emissions.

4.2 New Hampshire Clean Power Strategy

In January 2001, Governor Shaheen announced an integrated strategy to reduce emissions of sulfur dioxide, oxides of nitrogen, mercury, and carbon dioxide from fossil-fueled power plants.[52] The New Hampshire Clean Power Strategy (strategy) includes market-based measures, such as banking and trading of emission reductions under a strictly controlled and monitored overall emissions cap. As described in the strategy, the average annual CO_2 emission rate for new, combined cycle power plants burning natural gas is 760 pounds/megawatt hour (lbs/MWh), while the average annual CO_2 emissions rate from New Hampshire's existing fossil fuel-burning power plants is closer to 2,300 lbs/MWh, over three times higher. In order to reduce GHG emissions, the strategy calls for a 7% reduction from 1990 baseline CO_2 emissions from New Hampshire's existing coal- and oil-burning power plants. These reductions will result in a 10% reduction from current annual emissions from these sources, eliminating approximately 400,000 tons of CO_2 emissions. Legislation to implement the strategy was considered in the 2001 legislative session (House Bill 284) and was retained to be taken up again in the 2002 legislative session.[53]

[52] New Hampshire Clean Power Strategy (*CPS*) An Integrated Strategy to Reduce Emissions of Multiple Pollutants from New Hampshire's Electric Power Plants, see http://www.des.state.nh.us/ard/NHCPS_draft.pdf.

[53] On November 28, 2001, the committee of jurisdiction forwarded an amended bill to the full House for its consideration. The amended HB284 called for a reduction of CO_2 to 1990 emission levels (approximately 3% below current levels) and a lower cap to be recommended by 2004 for implementation after 2010.

4.3 Electric Industry Restructuring - Consumer Choice

The first of New Hampshire's electric industry restructuring laws was enacted in May of 1996 to allow retail competition, which was expected to begin in July of 1998. Although dregulation was delayed as a result of litigation, two of the state's electric utilities, Granite State Electric Company (GSEC) and the New Hampshire Electric Cooperative (NHEC), opened their service areas to competition 1998 and January of 2000, respectively. The state's largest utility, Public Service Company of New Hampshire (PSNH), filed suit over who should pay for prior investments ("stranded costs") and other issues, resulting in the utility-by-utility phase-in. The successful settlement of that litigation resulted in PSNH opening their service territory to competition on May 1, 2001. The State's other two investor-owned electric utilities, Unitil (parent company of Concord Electric Company and Exeter and Hampton Electric Company) and Connecticut Valley Electric Company, have not yet opened their service territories to competition.[54]

It is hoped that retail competition will gather momentum for both GSEC and NHEC customers now that a settlement has been reached between the State and PSNH under the terms of Senate Bill 472 (SB 472). Full implementation of a deregulated market, in which customers can choose their electricity supplier, is not expected to occur until at least 2004, when PSNH will complete the sale of its fossil fuel and hydropower electric generating plants.

Part of the legislation establishing deregulation requires the Public Utilities Commission (PUC) to specify how electricity suppliers make information available to customers about the environmental effects caused by their generating plants. In addition, deregulation will bring new suppliers to the market with a variety of environmental characteristics.[55] Customer research and early experience with retail choice indicate that customers are concerned about the environmental impacts of electrical generation, and are likely to make purchasing choices based on those concerns. SB 472 also established a system benefits charge (SBC) of $0.002 (2 mills) per kilowatt hour (kWh) to help support low-income assistance and energy-efficiency programs in the state. In 2001, House Bill 489 (HB 489) increased the total system benefits charge to a maximum 3 mills per kWh for these programs, increasing funding for energy-efficiency programs by up to 1 additional mill. This new emphasis on promoting energy efficiency in commercial/industrial and residential sectors is important to reducing greenhouse gas emissions. System-benefits-charge amounts used to support energy-efficiency programs in other states are shown in the table below. With the passage of HB 489, New Hampshire's SBC is now comparable to those charges in other states undergoing restructuring.

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[54] For further information on the status of electricity in New Hampshire, see http://www.nhecs.org/.
[55] For futher information about disclosure of environmental attributes of electricity, see http://www.rapmaine.org/disclose.html.

TABLE 4-1 Comparison of System Benefit Charges in States Undergoing Electric Deregulation[56]

State	Total System Benefit Charge in mills/kWh	Portion Designated for Energy Efficiency in mills/kWh
Arizona	1.4	0.4
California	3.0	1.3
Connecticut	4.0	3.0
Delaware	0.3	0.18
Illinois	0.7	0.03
Maine	2.3	1.5
Massachusetts	3.7	3.0
Montana	1.1	0.7
Pennsylvania	0.8	0.1
Rhode Island	2.6	2.1
Wisconsin	2.2	1.2
Average	**2.0**	**1.2**

Note: One mill/kWh equals $.001 per kilowatt hour

As part of overall restructuring, New Hampshire should encourage and promote alternative energy suppliers who market renewable energy resources. Renewable energy sources are those based on non-depletable fuels such as solar, wind, geothermal, tidal, biomass and, in some cases, hydroelectric and waste to energy facilities. President Bush's National Energy Policy recommends expanding existing alternative fuels tax incentives to include landfill gas, wind and biomass.

4.4 New Gas-Fired Combined Cycle Generation

Historically, fossil fuel plants have generated electricity in a conventional steam cycle. Fuel is burned to turn water into steam, and the steam drives a steam turbine generating power. This cycle captures the heat energy of combustion, but fails to capture the mechanical energy of expanding gases during combustion. In recent years advances have been made using combined-cycle systems, in which fossil fuel combustion is used to drive a combustion turbine, and waste heat from this process is captured to drive a conventional steam generator. By capturing the energy in the hot gases exiting the gas turbine, combined-cycle systems can achieve a total thermal efficiency over 50 percent.

Other advantages to gas-fired combined cycle (GFCC) include:

[56] Kushler, M. and White, P, September 2000. *A Review and Early Assessment of Public Benefit Policies Under Electric Restructuring - Volume 2: A Summary of Key Features, Stakeholder Reactions, and Lessons Learned to Date – Summary Table of Benefit Programs and Electric Utility Restructuring (update 3/02/01), see* http://www.aceee.org/pubs/u003.htm.

- Smaller geographic plant footprint.
- Lower air pollution emissions.
- Absence of large coal piles on-site.
- Most GFCC system equipment is prefabricated allowing modular expansion.

Natural gas emits approximately one-third less CO_2 per Btu than coal. In the U.S., 75 percent of planned new capacity at utilities will be fueled by natural gas.[57] Two gas-fired combined cycle electrical generating plants are now under construction in New Hampshire.[58] New Hampshire should continue to promote natural gas electric generating plans in-state and throughout the region and nation.

4.5 Renewable Energy Resources

4.5.1 Overview

Hydropower generation is responsible for 82 percent of current renewable electricity generation (1997 figures) in the U.S. It is not included in this discussion however, because its growth is severely limited by the availability of suitable sites and the difficulty in obtaining permits for new dams. Maintenance and improvements of existing hydropower sites should continue wherever economically and environmentally appropriate.

Geothermal, wind, and solar are more viable options for significantly increasing renewable electricity generation. Geothermal generation is theoretically limited by the regeneration rate of this resource compared to solar and wind generation where limits on regeneration are much less significant. New Hampshire has two pieces of legislation currently being considered, House Joint Resolution 5 (HJR 5) and House Bill 701 (HB 701), which direct that new and renovated state-owned buildings integrate renewable energy concepts into the design and construction. New Hampshire should continue to promote the use of renewable energy in state-owned buildings.

Biomass generation facilities emit little, if any, net carbon over time when they utilize waste wood or wood that is sustainably harvested (i.e., when harvested land is replanted).[59] In New Hampshire, wood waste from wood-based industries is burned in biomass electric generation facilities which also diverts these materials from landfill disposal.
One step that is critical to further development of renewable energy is an impartial analysis and identification of the technical capability of each generator to use intermittent systems and technologies available to achieve necessary power quality. There should be continued monitoring of energy storage technology to identify a cost-effective non-fossil fuel back up to allow greater deployment of intermittent systems.

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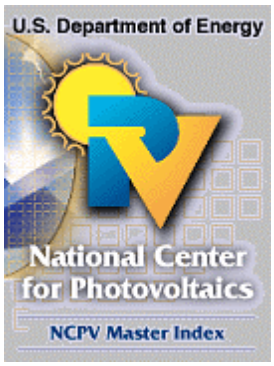
[57] For further information, see http://www.resourcesolutions.org/.
[58] For additional information, see http://www.aesgraniteridge.com/ and http://www.resourcesolutions.org/.
[59] Michael C. Brower et al., Union of Concerned Scientists, Powering the Midwest: Renewable Electricity for the Economy and the Environment, Cambridge, MA, 1993.

The U.S. Department of Energy's Energy Efficiency and Renewable Energy Network (EREN) provides a comprehensive resource for energy efficiency and renewable energy including available technologies, financial incentives, and technical information.[60] EREN also provides access to over 600 links and 80,000 documents.

4.5.2 Promote Photovoltaic (PV) Systems



Solar photovoltaic (PV) systems offer considerable benefits relative to fossil-fueled and nuclear generation.[61] PV systems are modular and silent, create no pollution in operation, can be operated unattended, and require little maintenance. They are usually small-scaled and used at the location that the power is consumed avoiding the need for investments in transmission infrastructure and loss of electricity across the hundreds of miles of transmission lines. PV systems are dependent on the sun and therefore cannot just be turned on when there is demand. However, peak PV generation generally coincides with afternoon peaks in electricity demand, when electricity is most valuable. Some regions in the country are implementing time-of-day pricing, charging customers more when demand is high. PV systems would be particularly advantageous under a time-of-day pricing regime. This coincidence also means that PV generation will usually displace the higher-emitting fossil-fueled plants that operate during peak periods thus improving air quality on a regional basis.[62] Finally, New Hampshire has implemented a "net-metering" rule, which allows unused generation from small solar (and wind) units to be credited to the customer against future power consumption. In other words, an individual's meter will "run backwards" if they are producing excess power and it will be credited against their future bill. Total PV energy production for the State is 86,000 kWh/year, which eliminates more than 642 tons of CO_2 per year and saves an estimated $8000 in electrical costs.[63]

In the last two years the Energy Office has developed 16 PV projects in the State through its annual Competitive Renewable Energy Technology Grants Program. New Hampshire should continue to fund and promote this program. In addition, the Solar-on-Schools Program has sponsored the installation of 1 kW PV systems on 13 New Hampshire high school rooftops, representing more than 12 percent of school districts in the state. Curriculum materials are also distributed in the schools through the program, which last year provided training for more than 70 educators. These public-private partnerships, part of New Hampshire's inclusion in the federal Department of Energy's Million Solar Roofs Initiative (MSRI) (also see Section 5.3.7) should continue. New Hampshire currently ranks 7th in the nation for number of PV systems installed under MSRI.

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[60] Energy Efficiency and Renewable Energy Network (EREN), US Department of Energy, see http://www.eren.doe.gov.

[61] For additional information on photovoltaics, see http://www.nrel.gov/ncpv/.

[62] STAPPA & ALAPCO, Reducing Greenhouse Gases & Air Pollution, A Menu of Harmonized Options, Final Report, Washington, D.C., October 1999, see http://www.cleanairworld.org/scripts/us_temp.asp?id=307 .

[63] Governor's Office of Energy and Community Services, Concord, NH, 2001.

4.5.3 Landfill Gas to Energy Project

Landfill gas to energy facilities represent a very small percentage of total renewable energy generation in the State. Two sites, Manchester Landfill and Pelham Landfill, are actively capturing and converting the gas to energy. Gas produced by landfills usually includes methane, sulfur and chlorine compounds and numerous other organic compounds. Landfill gas to energy plant development should be encouraged. Most of the State's landfills have been covered and capped. Current gas capture technology can make it economically feasible to produce energy from landfill gas at small to mid-sized landfills.[64]

4.5.4 New Hampshire Wind Study Project

Electricity generated by wind turbines is currently the lowest cost of any renewable technology. For optimally sited wind turbines, costs have dropped from $0.30/kWh in 1981 to under $0.04/kWh.[65] Wind turbines emit no GHG emissions during operation.

The New Hampshire Wind Study Project was created in 1997 by a joint effort between the Energy Office (through Federal Department of Energy funding) and Northeast Utilities (NU). Currently, NU is providing full funding for the project. Four towers were erected to determine the feasibility of generating electricity from wind in the state; currently, towers on Mt. Sunapee and in Dixville Notch are involved in the project, which may be continued for another year. Data collected to date, and data from previous studies (in New Hampshire and New England), show that wind energy is possible in New Hampshire. Several private windmills are operating in New Hampshire. The recent passage of the net-metering law allows for individual wind turbines to sell electricity back to the area electrical generator when supply exceeds demand, helping to offset the up-front installation capital costs and ongoing generation values.

Despite the favorable wind-producing topography and conditions, several obstacles need to be overcome. Most of the favorable wind sites, for example, are located on federal lands, and the federal government has banned the erection of towers on federally owned land. Additionally, since the State places a high value on its natural environment and vistas, the siting of a windmill may provoke strong local resistance. Overall, New Hampshire has the potential for wind produced power and more study is warranted. Further information on wind energy can be found at the American Wind Energy Association website.[66]

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[64] For more information on using landfill gas for electric energy generation, see http://www.eren.doe.gov/cities_counties/landfil.html.

[65] STAPPA & ALAPCO, Reducing Greenhouse Gases & Air Pollution, A Menu of Harmonized Options, Final Report, Washington, D.C., October 1999, see http://www.cleanairworld.org/scripts/us_temp.asp?id=307.

[66] American Wind Energy Association, see http://www.awea.org/default.htm.

4.5.5 Undertake a Geothermal Energy New Hampshire Feasibility Study

Geothermal energy is the naturally occurring heat under the Earth's surface. This heat can exist as steam or hot water. It originates from the heat remaining in the Earth's molten core, from friction caused by the shifting of the continental plates and from the radioactive decay of naturally occurring elements. Geothermal reserves may be tapped to provide direct heat for residential, commercial, and industrial uses. Power production from geothermal resources involves locating and drilling into geothermal reservoirs, and pumping the steam or hot water to a power plant at the surface.[67] Though the most readily available geothermal resources in the U.S. are in a small number of western states, New Hampshire could conduct a geothermal energy feasibility study to determine if there are smaller resources that may be economically viable to develop in New Hampshire.

4.5.6 Encourage Accreditation Initiative for Green Power Pricing

The Center for Resource Solutions (CRS), a nonprofit organization focusing on sustainability, manages the first independent accreditation initiative for utility green power pricing programs. The initiative, called "Green-e", is designed to recognize and accredit best practice utility programs that offer qualified green electricity options to their customers.[68] To receive accreditation, utilities will have to meet stringent standards for consumer and environmental protection in addition to using renewable resources. Accredited utilities will undergo an annual, independent verification documenting that they delivered promised green power to customers. New Hampshire should encourage power producers and marketers to participate in this program in order to make environmentally preferable power more readily available to retail customers.[69]

4.6 Use of Nuclear Power

Although controversial, nuclear is clean power with essentially no emissions and reduces demand on use of fossil fuels. In New Hampshire, past investment in nuclear power led to some of the highest electric rates in the country. In addition, disposal of the radioactive waste generated at nuclear power plants is still a major unresolved environmental issue. At present, New Hampshire does not have plans to expand its nuclear power capacity.

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[67] For additional information on geothermal energy, see http://www.eren.doe.gov/RE/geothermal.html and http://yosemite1.epa.gov/estar/consumers.nsf/content/ghp.htm.

[68] For additional information on Green-e, see http://www.green-e.org/.

[69] For additional information on green pricing, see http://www.rapmaine.org/green.html.

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5.0 COMMERCIAL/INDUSTRIAL MITIGATION STRATEGIES

5.1 Overview

Strategies focused on the commercial and industrial sector seek to reduce GHG emissions (mainly CO_2) through energy conservation and efficiency, and through the utilization of alternative energy technologies and fuels. While global climate change remains a key environmental driver, the incentives for almost all strategies that focus on conservation, efficiency, and alternative energy options are the economic benefits to the end user. In most cases, the capital costs for these strategies can be recovered within two to five years.

In the commercial buildings sector, emissions are generated primarily from space heating, lights and fixtures, space cooling, and office equipment. The strategies used to reduce emissions include energy-saving measures, such as reducing overall power consumption and high-efficiency replacement equipment. Improving energy efficiency means changing energy consuming equipment or practices to reduce the energy used, without changing the ultimate service that the equipment or practice provides. Higher-than-average efficiency technologies exist for almost every use. Examples include installing efficient new heating systems in buildings, and energy efficiency improvements such as increased building insulation, and optimization systems for lights and heating/cooling, and more efficient windows. Design improvements, which are most cost-effectively achieved at the time of construction, also present significant opportunities to improve energy efficiency. Designs that take advantage of sun and shade, storage of solar energy (even in passive materials such as floor tile), and more technologically advanced insulation help to improve energy efficiency. In addition, updated building codes (and their enforcement) can play an important role in ensuring greater energy efficiency.

Alternative energy technologies and fuels involve switching to energy sources that result in lower GHG emissions. For example, natural gas is less carbon intensive than oil and coal, and natural gas systems are often times more efficient in operation than systems those that use oil and coal. The use of renewable energy sources result in zero net CO_2 emissions. Renewable energy options include passive solar heating, active solar water and space heating, and wind and solar electricity generation. Alternative energy technologies and fuels also have ancillary environmental benefits over traditional fossil fuels, including significantly reduced emissions of particulate matter, sulfur compounds (SOx, which lead to acid rain), nitrogen oxides (NOx, which contribute to the formation of ground level ozone and nitrates), carbon monoxide, and non-methane volatile organic compounds (VOCs).

The strategies described below focus primarily on assistance to businesses in the form of technical assistance to help businesses reduce their energy costs. By improving energy efficiency, conserving energy, and pursuing alternative energy and fuel technologies (more efficient technologies, less carbon intensive fuels), built-in economic incentives help drive reductions in GHG emissions.

5.2 Energy Efficiency and Conservation

5.2.1 Energy Star Programs

U.S. Environmental Protection Agency's Energy Star Programs[70] promote energy-efficiency improvements in existing commercial buildings. Partners (e.g, small businesses, municipalities) voluntarily commit to energy efficiency upgrades on a per-building (square footage) basis and receive technical assistance and recognition. The Green Lights program within Energy Star focuses on high-efficiency fluorescent lighting (T-8, 32-watt bulbs with electronic ballasts) and appropriately placed motion sensors that can significantly reduce lighting energy use and emissions. Typically, partners experience average annual energy savings from 20 to 30 percent for upgrades that yield a resulting internal rate of return between 15 and 35 percent. With these programs, the focus is on treating buildings as systems rather than on specific building components. Both programs are performance-based, rather than prescriptive, and promote cost-effective upgrades.

New Hampshire can promote Energy Star programs (such as Energy Star Buildings and Green Lights) by providing information on energy conservation and efficiency via official state documents sent to New Hampshire businesses, through links on State websites, through promotion of New Hampshire's Greenhouse Gas Registry (see Section 8.2), public service announcements, consumer/contractor education initiatives, and by encouraging lending institutions to provide information on the program to clients seeking construction loans. Energy efficiency is critical to reducing energy use thereby reducing greenhouse gas emissions.

5.2.2 Small and Cool Initiative

Small and Cool is a collaborative effort between the Northeast States for Coordinated Air Use Management (NESCAUM)[71] and the non-profit Clean Air-Cool Planet organization.[72] It provides direct assistance to small businesses to reduce greenhouse gas emissions through energy efficiency measures. Participating companies provide energy use information based on an internal energy audit. *Small and Cool* provides technical assistance in identifying and quantifying GHG reduction strategies. Greenhouse gas emission reductions would then be documented in the New Hampshire greenhouse gas registry.

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[70] US EPA Energy Star website, see http://www.energystar.gov/.
[71] Northeast States for Coordinated Air Use Management (NESCAUM), see http://www.nescaum.org/.
[72] Clean Air-Cool Planet, see http://www.cleanair-coolplanet.org.

5.2.3 Industries of the Future

The *Industries of the Future* initiative is a partnership between WasteCap of New Hampshire[73] and the Energy Office. Through a grant from the Department of Energy's Office of Industrial Technologies, the initiative assists the State's industries working in metals, forest products, and chemicals/rubber/plastics to identify and implement efficiency and waste reduction through advanced technology. The goal of the program is to reduce energy use and pollution while increasing profitablility.

5.2.4 Commercial/Industrial Energy Codes and System Benefit Charges

The Energy Office is also conducting a study to assess possible improvements to New Hampshire's commercial/industrial energy code. New Hampshire should adopt changes to the energy portions of the Commercial Building Code to bring it into conformity with the latest revision to ASHRAE Standard 90.1, and continue to sponsor educational workshops relative to residential and commercial energy codes.

New Hampshire should also consider strict building and equipment codes for industrial construction, targeting opportunities for increased energy conservation and efficiency. The State should also increase training efforts for builders, code officials and contractors with the energy provisions of the existing code including new techniques and technologies for greater energy efficiency and occupancy comfort.

As discussed in Section 4.3, previous and proposed electric restructuring legislation will establish a system benefit charge for energy efficiency programs for commercial and industrial customers. New Hampshire electric utilities have filed their proposed "Energy Efficiency Core Programs" as directed by the New Hampshire Public Utilities Commission. The proposed program of outreach, incentives, and rebates is self-directed by a utility collaborative. DES supports the establishment of consistent energy efficiency core programs across all utilities but feels it is important to establish an independent administration. DES is working with the Energy Office and other parties to provide input into the design of these important public programs that the New Hampshire Public Utilities Commission requires.

5.2.5 Load Response Programs

The Independent System Operator for the New England power pool (ISO-New England) has initiated a program in the summer of 2001 that will enable businesses to reduce power consumption and sell their reduced load back to the power grid.[74] This concept is being tested in a pilot program. An interested business needs to acquire the appropriate software through ISO-New England to participate in this program. Load reductions can be achieved through energy conservation or use of distributed power generation. Distributed power generation is discussed further in Section 5.3.5. The economic benefit from selling reduced load back to the power grid

[73] WasteCap Resource Conservation Network WasteCap of New Hampshire, see http://www.wastecapnh.org/.
[74] For more information load response program, see http://www.iso-ne.com/main.html.

will be augmented if the load reduction is the result of energy conservation. This program provides the State an opportunity to encourage commercial/industrial conservation which reduces greenhouse gas emissions by reducing energy use.

5.3 Alternative Energy Technology and Fuels

5.3.1 Promote the Use of Combined Heat and Power (Cogeneration)

Cogeneration of heat and power is an increasingly popular method of reducing energy use and emissions.[75] Classical cogeneration systems use a steam boiler and back-pressure turbine. These systems have a power-to-heat ratio of 40 - 60 kilowatt hours per million British Thermal Unit (KWhrs/MMBTU) and are relatively less efficient compared to newer gas turbine systems. With gas turbine technology, the heat from the flue gases is captured and transferred to low and medium pressure waste heat boilers. These systems have a power-to-heat ratio of 70 - 80 KWhrs/MMBTU. Gas turbine plants are also relatively economical. Overall, these systems often result in 20 to 40 percent reductions in energy use compared to conventional systems. President Bush's National Energy Policy calls for encouraging combined heat and power projects by offering tax breaks and flexible permitting.

The State should promote the use of combined heat and power in industrial and commercial applications.

5.3.2 Promote the Expansion and Use of Natural Gas Service

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Oil is the most common fuel used for heat in industrial and commercial applications in New Hampshire. Natural gas as a fuel produces roughly one third less carbon dioxide per Btu than distillate oil (i.e., diesel, home heating oil), and compares even better for residual oil (i.e. "heavy oil," which is used in some industrial and commercial applications). In addition, modern natural gas boilers tend to be significantly more efficient than existing oil fired boilers.

However, natural gas is only an option where it is available. Within the last five years, two major natural gas pipeline projects have provided opportunities for expanded use of natural gas in New Hampshire. Natural gas transmission lines from western Canada and Nova Scotia have been extended into Portland, Maine, and connected to an existing line in northeastern Massachusetts, which is fed from the Gulf of Mexico. One of two existing natural gas lines servicing central New Hampshire from Massachusetts is scheduled to be replaced with a larger service (8" pipeline to 20" pipeline) in the summer of 2002. The connection of the natural gas pipelines from Canada and the Gulf, along with the increased service to central New Hampshire provides the State with opportunities to expand the use of natural gas as an alternative to oil and coal for residential, commercial, industrial, and electric generation applications.

New Hampshire can promote the environmental benefits of natural gas service in the State, and the use of natural gas as an alternative to oil and coal for heat, hot water, and other purposes.

[75] For United States Combined Heat and Power Association, see http://www.nemw.org/uschpa/.

5.3.3 Conversion of Industrial Oil-Fired Boilers to Natural Gas

The availability of natural gas in northern New Hampshire has spurred plans for the replacement of oil-fired boilers (and in one case a wood-fired boiler) with highly efficient, cost-effective natural gas boilers. Three paper mills, which generate power for their industrial processes on-site, have proposed replacement of oil-fired steam boilers, two with natural gas turbine cogeneration,[76] and one with a cogeneration natural gas power boiler. In addition, another central New Hampshire industrial facility that produces electricity on-site for its processes has converted its oil-fired power production device with a natural gas combustion turbine.

New Hampshire could promote the conversion of industrial oil-fired boilers to natural gas by providing cost-effectiveness data and other information to industrial sources, and by considering conversions as permit conditions and/or compliance provisions.

5.3.4 Co-Firing with Biomass and Gas

The term co-firing refers to the burning of two fuels simultaneously in a single boiler. Coal-fired boilers can be co-fired with biomass or gas, and since both of these fuels have a lower carbon-to-hydrogen ratio than coal, the process reduces CO_2 and mercury emissions. Growing trees and crops sequesters carbon, offsetting the carbon released during combustion. Thus, sustainably harvested wood and crops are carbon-free fuels. Wood waste (such as from logging, pulp and paper production, and the furniture industry) is the most promising biomass fuel for co-firing in New Hampshire, though there is a concern that re-chipping to make wood waste more efficient as a fuel may make it too expensive to be competitive with coal at about $20 per ton. While significant boiler modifications are normally not needed, additional fuel handling equipment is usually necessary, such as a fuel receiving and storage area, a truck tipper and log stacker, fuel feeders, separators, chippers, sizing equipment and conveyor belts.

Natural gas can also be used for co-firing. Most boiler modifications are relatively simple, though some boilers are more difficult to modify. Necessary additional fuel handling equipment is minimal. New Hampshire could pursue means to encourage retrofits of existing fuel handling systems to manage these alternative fuels possibly through low interest loans or grants.

5.3.5 Distributed Power Generation

Distributed power generation is the generation of power by an industry at the location that the power is being consumed (as opposed to using power supplied by a licensed utility, or the "grid", in the traditional manner).[77] Diesel engines have long been used as distributed power sources to

[76] Cogeneration is a term used to describe the process by which the exhaust gas or waste heat is captured and used to the advantage of the facility. A typical example is when the high pressure steam from a primary boiler is used to generate power, and the exhaust steam (low pressure) is used in a secondary boiler for heat production.

[77] For a general overview of distributed power generation, see http://www.distributed-generation.com/Library/Cogeneration_in_Manufacturing.htm.

provide emergency back-up power to industry and emergency services. Recently, however, there has been an increase in the use and consideration of distributed power due to new technologies and concerns over the cost and reliability of power. Though new diesel engines are significantly cleaner and meet current Reasonably Available Control Technology (RACT) for NOx, their GHG emissions are significantly higher than power plants that have emission controls, or burn cleaner fuels. Although there are state regulations (i.e., NH Code of Administrative Rules Chapter Env-A 3700 NOx Emissions Reduction Fund for NOx-Emitting Generation Sources[78]*)* that encourage installation of emission controls on diesel engines, these controls would not address GHG emissions. The use of natural gas and alternative technologies need to be encouraged as a method for meeting demand for distributed power.

Advances in fuel cell and microturbine technologies have made smaller scale combined heat and power systems, from several kilowatts (KW) to several hundred KW in size, more cost-effective in some applications. These distributed generation technologies are most appropriate for use in hotels, hospitals and large office buildings, serving both electricity and heating/cooling needs. When waste heat is fully utilized, these units can achieve efficiencies over 80 percent,[79] compared to 35 percent efficiency for many older coal burning electrical generation plants, reducing energy use and its associated greenhouse gas emissions.

5.3.6 Purchase of Renewable Energy Resources

As described in Section 4.3, electric deregulation will allow customers to choose their supplier of electricity.[80] Customers will also be able to pool their purchases to negotiate better prices or terms. New Hampshire should encourage and promote alternative energy suppliers who market renewable energy resources.[81] See Section 4.3 for a further discussion of encouraging renewable energy resources.

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[78] Administrative Rules can be found at the NH Department of Environmental Services Website, see http://www.des.state.nh.us/.

[79] STAPPA & ALAPCO, Reducing Greenhouse Gases & Air Pollution, A Menu of Harmonized Options, Final Report pages 31-34, Washington, D.C., October 1999, see http://www.cleanairworld.org/scripts/us_temp.asp?id=307.

[80] For further information on the status of electricity deregulation in New Hampshire, see http://www.state.nh.us/governor/energycomm/eir.html .

[81] Interstate Renewable Energy Council, see http://www.irecusa.org/.

5.3.7 Million Solar Roofs Initiative

The Million Solar Roofs Initiative (MSRI), which includes both photovoltaic and solar water heating systems for homes, commercial or institutional and government buildings, was launched by President Clinton in 1997.[82] The goal is to install one million solar energy systems across the United States, including 500 in New Hampshire, by the year 2010. The federal Department of Energy is supporting partnerships in the Northeast comprised of the building industry, local and state government agencies, the solar industry, electric utilities, universities, and other environmental organizations, to remove market barriers, foster incentives, and strengthen the demand for solar energy technologies.

The Energy Office has contracted with the Northeast Sustainable Energy Association (NESEA) to lead workshops for all interested parties on accelerating the use of solar energy in New Hampshire. NESEA will also develop an MSRI implementation plan for New Hampshire, including the establishment of a Solar Energy Working Group, comprising the building industry, environmental organizations, government officials, and representatives of the solar-power industry.

New Hampshire, through the Energy Office, is a formal partner with Department of Energy in the Million Solar Roofs Initiative, and is registering all local solar installations (high schools in the Solar on Schools program, eligible Renewable Energy Technology Grant Program recipients, etc. currently 29 across the state, making New Hampshire 7th in the nation) with the national program.[83]

More than 25 New Hampshire homes, businesses, and science centers participated in the October 2000 National Tour of Solar Homes sponsored and publicized in New Hampshire by the Energy Office, which is twice as many homes as last year. More than 300 people visited tour sites, and solar advocates in Peterborough organized a solar fair in a downtown park as part of the day's events. The Environment Committee of the New Hampshire chapter of the American Institute of Architects offered guided tours of solar homes. The Society for the Protection of New Hampshire Forests offered tours of its headquarters in Concord. This year's tour took place on October 13, 2001.

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[82] For more information on DOE's Million Soar Roofs Initiative, see http://www.eren.doe.gov/millionroofs/.
[83] For Governors Office of Energy and Community Services Renewable Energy Programs, see http://www.state.nh.us/governor/energycomm/sep/renewable.html.

5.4 Waste Reduction and Efficiency

5.4.1 Sources of Greenhouse Gases from Non-Energy Sources

Products and goods can indirectly cause emissions of greenhouse gases. Extracting raw materials, manufacturing, transporting finished goods, packaging, and disposal of the product all use energy and hence result in emissions of greenhouse gases. Using products more efficiently to ultimately reduce waste also reduces emissions of greenhouse gases. For example, making products and goods from recycled materials reduces the amount of raw materials that have to be extracted, transported and processed. Often energy consumption is less for manufacturing recycled products compared to making the same product from raw materials. In addition, less waste results in less decomposition of waste avoiding emissions of methane from landfills. The more efficiently we use products and goods from obtaining the raw materials to manufacturing, to use and disposal; the less greenhouse gas emissions are generated because less energy is used or less new products are needed.

In addition, certain products can be direct sources of greenhouse gases. Operation and maintenance of industrial equipment, particularly electrical equipment, is often a source of emissions of other greenhouse gases. Though the relative quantity of these greenhouse gases may be low, they can be significant because they can have very high global warming potentials (see Section 2.1). Such gases include:

Halogenated Fluorocarbons (e.g., chlorofluorocarbons (CFCs), halons, methyl chloroform, carbon tetrachloride, methyl bromide, and hydrochlorofluorocarbons (HCFCs)) – sources include refrigerants and other heat-transfer fluids, air conditioners and other cooling equipment, foaming agents, fire extinguishers, and solvents.

Sulfur Hexafluoride (SF_6) – Used in heavy industry as an electric insulator; also used in high-voltage equipment and cable cooling systems.

Ozone (O_3) – not emitted directly by human activity, ozone is formed from the combination of a number of man-made emissions – nitrogen oxides and volatile organic compounds (VOCs – found in many commercial solvents), and carbon monoxide.

5.4.2 Reducing Greenhouse Gas Emissions from Non-Energy Sources

DES has a broad-based pollution prevention program focused on businesses and individuals. Pollution Prevention (P2) means the use of materials, processes, or practices which reduce or eliminate the creation of pollutants or wastes at the source, or minimize their release into the environment prior to recycling, treatment, or disposal. These pollution prevention activities reduce emissions of greenhouse gases through three primary means: source reduction by eliminating the source of emissions, reuse of materials to extend the life of products (hence less production of new materials), and recycling to recover the resources. DES pollution prevention

initiatives include technical support to small business, award programs, and extensive public outreach and education.[84]

In addition, materials containing the greenhouse gases generally described as halogenated fluorocarbons (i.e., ozone-depleting substances) have been specifically targeted under the *Montreal Protocol* and the *Copenhagen Amendments.* These initiatives control the production and consumption of halogenated fluorocarbons. The U.S. phased out the production and use of all halons by January 1, 1994, and phased out the production of CFCs, HCFCs, and other ozone-depleting substances (ODSs) by January 1, 1996.[85] In coordination with federal regulation, DES put in place recycling and reclaimation procedures for equipment that still contain these chemicals. However, perfluorinated carbons (PFCs) and hydrofluorocarbons (HFCs), a family of CFC and HCFC replacements not covered under the *Montreal Protocol,* are still in use and are powerful greenhouse gases.

5.4.3 DES Green Lodging Initiative

A grant through US EPA Region I was issued to DES to demonstrate how to reduce solid waste from the New Hampshire lodging industry. Reducing solid waste is essential to reducing methane emissions from landfills. In New Hampshire where tourism is an important part of the economy, the hospitality industry is a large contributor to the solid waste stream. DES promotes "green lodging" and has designed a manual with specific waste reduction practices that can be adopted by members of the lodging industry. The guide, entitled *Staying Green: A Guide To Waste Management For the Lodging Industry*[86] provides a comprehensive list of actions that members of the lodging industry can take to reduce total waste. Waste reduction has the added benefit of lowering overall emissions by reducing the demand for resources used by the lodging industry. When less products (e.g., paper, shampoo, etc.) and resources (e.g., water, electricity) are used for the same activity by the same amount of people, then emissions from manufacturing, product use and disposal are reduced. A wide variety of solid waste assistance for commercial waste reduction is available through the DES Waste Management Division.[87]

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[84] New Hampshire Pollution Prevention Program, see http://www.des.state.nh.us/nhppp/.
[85] EPA Ozone Protection Programs, see http://www.epa.gov/ozone/index.html.
[86] This publication is available through the DES Public and Permitting Unit (PIP) or on-line at http://www.des.state.nh.us/pcas/greenlodging/.
[87] See http://www.des.state.nh.us/pcas/.

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6.0 RESIDENTIAL MITIGATION STRATEGIES

6.1 Overview

Similar to the commercial/industrial sector, strategies focused on the residential sector seek to reduce GHG emissions (mainly CO_2) through energy conservation and efficiency, and through the utilization of alternative energy technologies and fuels. While global climate change remains a key environmental driver, the incentives for almost all strategies that focus on conservation, efficiency, and alternative energy options are the economic benefits to the end user.

Improving energy efficiency means changing energy consuming equipment or practices to reduce the energy used, without changing the ultimate service that the equipment or practice provides. Higher-than-average efficiency technologies exist for almost every end use. Examples include replacing an old refrigerator or washing machine with an energy efficient model or installing efficient new heating thermostats or energy efficient lighting. The Energy Office provides resources to help individuals improve the energy efficiency of their homes.[88]

Aside from the energy efficiency options described above, fuel use (and hence CO_2 emissions) can be reduced through product cycling. Product cycling entails changes in the ways goods and services are used by consumers. Reducing, reusing, and recycling products avoids CO_2 emissions on several levels. Emissions associated with product manufacture, packaging, distribution, use, and handling/disposal/decomposition of waste are reduced.

Education of consumers and easy access to higher efficiency alternatives are essential to a practical, voluntary approach to reducing greenhouse gas emissions. Maximizing emission reductions through voluntary measures will reduce the need for more regulatory approaches in the future.

6.2 Energy Conservation and Efficiency

6.2.1 Residential Energy Codes and System Benefit Charges

New Hampshire adopted a new residential energy code in a 1999 joint effort of the Energy Office, the New Hampshire Public Utilities Commission, and the State's building industry. The new code will result in a significant reduction of energy use within the residential sector. Since the enactment of the new code, the Energy Office and the Public Utilities Commission have sponsored 21 workshops around the state for builders, architects, engineers, contractors, code enforcement officers, and others to introduce and discuss the new residential energy code.

As directed by the New Hampshire Public Utilities Commission, the New Hampshire electric utilities have filed their proposed "Energy Efficiency Core Programs" to establish consistent energy efficient core programs across all utilities. Refer to Section 5.2.4 for a further discussion

[88] Governor's Office of Energy and Community Services Energy Efficient Home Heating, see http://www.state.nh.us/governor/energycomm/assist.html.

of these programs.

6.2.2 Appliance and Equipment Standards

The National Appliance Energy Conservation Act of 1987 (NAECA) imposed energy efficiency standards on manufacturers of refrigerators, air conditioners, water heaters, furnaces, dishwashers, clothes washers and dryers, heating equipment, kitchen ranges and ovens, pool heaters and other minor products. In addition, the federal Energy Policy Act of 1992 established efficiency standards for new lamps, office equipment, electric motors and plumbing products.

Given the above standards as a starting point, New Hampshire can, in conjunction with other energy efficiency programs and through direct public service announcements, promote the replacement of older equipment and appliances with those meeting higher energy efficiency ratings.

6.2.3 U.S. Environmental Protection Agency's Energy Star Homes Program

The U.S. Environmental Protection Agency Energy Star Homes Program provides financial lending incentives offered by national lenders for newly constructed homes that receive a home energy rating of the set target level, currently 86 or greater. A newly constructed home or existing home must be inspected by an approved Energy Star technician who provides technical expertise in the proper methods for making a building more energy efficient. Once inspected and approved, the owner's home will receive an Energy Star Certification.[89]

New Hampshire can promote Energy Star Homes through public service announcements, consumer/contractor education initiatives, and by encouraging lending institutions to provide information on the program to clients seeking construction loans. Energy efficiency reduces greenhouse gas emissions by reducing energy use.

6.2.4 U.S. Department of Energy Weatherization Assistance Program

The federal Department of Energy's Weatherization Assistance Program (WAP) provides weatherization services to low-income clients to help them manage their energy costs by reducing energy bills with the added benefit of improving their health and safety. The Energy Office administers the Weatherization Assistance Program in New Hampshire, in partnership with New Hampshire's Community Action Agencies. Using advanced diagnostics and weatherization technology, the energy efficiency of dwellings occupied by low-income citizens is improved.[90] Because of limited funding, the Weatherization program was only able to make energy efficiency modifications to 7

[89] For further information on EPA's Energy Star Homes Program, see http://yosemite1.epa.gov/estar/homes.nsf/HomePage?OpenForm.

[90] New Hampshire Weatherization Assistance Program, see http://webster.state.nh.us/governor/energycomm/assist.html.

percent of the homes eligible for services in the 2000-2001 heating season.

6.2.5 Wood Stove Retirement/Replacement

Modern wood stove technologies feature increased fuel efficiency. Previous collaborative campaigns between the wood stove dealers and the Energy Office retired several hundred inefficient wood stoves. These efforts were augmented with public service announcements that emphasized modern wood stove efficiency and maintenance of wood stoves.[91] New Hampshire should again initiate a public outreach campaign to promote purchase of energy efficient wood stoves, particularly the new wood stoves that burn wood pellets (pellet stoves), which are significantly more efficient and burn cleaner than conventional wood stoves.

6.2.6 Financing Programs

A prime opportunity to improve energy efficiency occurs when buildings are under construction or when major renovations occur. Consumer resistance to higher initial capital cost from implementing energy efficiency measures during construction could be addressed through innovative financing programs, such as low interest loans targeted to energy efficient and low CO_2 technologies. Examples might include low interest loans for new efficient furnaces, super efficient appliances, storm windows, solar hot water heaters, and solar photovoltaics.

6.3 Alternative Energy Technology and Fuels

6.3.1 Million Solar Roofs Initiative

The goal of the Million Solar Roofs Initiative, launched by President Clinton in 1977, is to install one million solar energy systems across the United States by the year 2010.[92] Further discussion of this initiative is provided in Section 5.3.7.

6.3.2 Purchase of Renewable Energy Resources

Upon full electric deregulation, residential customers will choose their supplier of electricity.[93] Customers will also be able to pool their purchases to negotiate better prices or terms. New Hampshire should encourage and promote alternative energy suppliers who market renewable energy resources.[94] See Section 4.3 for a further discussion of encouraging renewable energy resources.

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[91] For further information on wood stove efficiency and emissions, see http://wlapwww.gov.bc.ca/air/particulates/rwssabi.html.
[92] For more information on DOE's Million Soar Roofs Initiative, see http://www.eren.doe.gov/millionroofs/.
[93] For further information on the status of electricity deregulation in New Hampshire, see http://www.state.nh.us/governor/energycomm/eir.html.
[94] Interstate Renewable Energy Council, see http://www.irecusa.org/.

6.3.3 Promote Conversion to Natural Gas

Conversion of home heating fuels to natural gas systems could reduce GHG emissions. Due to the increased availability of natural gas and expanded natural gas lines (see Section 5.3.2), New Hampshire should encourage home owners to consider installing or converting their heating systems to natural gas.

6.3.4 Promote Geothermal Options

New Hampshire should promote the use of geothermal heat pumps for home heating. Geothermal heat pumps are similar to ordinary air conditioners and heat pumps, but use energy stored in the ground instead of outside air to provide heating, air conditioning, and, in most cases, hot water. The U.S. Environmental Protection Agency Energy Star Program has more information on the benefits and technical specifications on geothermal heat pumps.[95]

6.4 Waste Reduction and Efficiency

6.4.1 Sources of Greenhouse Gases from Non-Energy Sources

Products and goods can indirectly cause emissions of greenhouse gases. Extracting raw materials, manufacturing, transporting finished goods, packaging, and disposal of the product all use energy and hence result in emissions of greenhouse gases. Using products more efficiently to ultimately reduce waste also reduces emissions of greenhouse gases. In addition, certain products such as appliances, electrical equipment, refrigerants, and aerosols, can be sources of greenhouse gases. Though the relative quantity of these greenhouse gases may be low, they may be significant because they often involve greenhouse gases with high global warming potentials. A discussion of these gases can be found in Section 5.4.1.

In addition to emissions from use of these products, land filling solid waste generates methane as a result of decomposition. Addressing greenhouse gas emissions from consumer products and the associated solid waste stream involves source reduction and encouraging reuse and recycling.

6.4.2 Reducing Greenhouse Gas Emissions from Non-Energy Sources

A discussion of DES' pollution prevention activities to reduce emissions of greenhouse gases through source reduction, reuse of materials, and recycling to recover the resources can be found in Section 5.4.2.[96] It also discusses specific programs to control production and consumption of the greenhouse gases generally described as halogenated fluorocarbons (i.e., ozone-depleting substances).[97]

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[95] For more information on Geothermal Heat Pumps from EPA's Energy Star Programs, see http://yosemite1.epa.gov/estar/consumers.nsf/content/ghp.htm.
[96] New Hampshire Pollution Prevention Program, see http://www.des.state.nh.us/nhppp/.
[97] New Hampshire Pollution Prevention Program, see http://www.des.state.nh.us/nhppp/.

6.4.3 Recycling Programs

Many state and local recycling programs that exist in New Hampshire have succeeded in reducing waste, and hence greenhouse gas emissions from waste disposal, by changing behavior. These programs include:

- Local Annual Amnesty Day.

  Many local communities are sponsoring annual amnesty days where residents can bring in hazardous products and other materials for recycling.

- Expanded Recycling Stations

  Expanded recycling stations accept more than standard recycling items and enable more organized separation of materials, enhancing more complete recycling.

By encouraging the expansion of existing recycling and hazardous product collection, New Hampshire can reduce GHG emissions through product cycling (reduces emissions associated with product manufacturing, packaging, distribution, use, and handling/disposal/decomposition of waste) and can help to address various other waste management and water resource issues related to improper handling and disposal of hazardous materials.

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7.0 CARBON STORAGE AND SEQUESTRATION

7.1 Overview

New Hampshire's forests currently represent a significant reservoir of carbon. Carbon is sequestered, or stored, in plants and trees through photosynthesis. Hence, as trees develop and forests mature the amount of carbon stored increases. Within a typical New Hampshire forest, carbon is distributed among the soil (57%), trees (35%), and litter and debris on the forest floor (8%). Forests constitute 84% of land area in New Hampshire making it the second most forested state in the Nation. New Hampshire forests sequester approximately 25 percent of all New Hampshire greenhouse gas emissions. In other words, of the approximately 17.8 million tons of greenhouse gases emitted annually by New Hampshire sources, forest growth results in a net removal of approximately 4.9 million tons of CO_2 (see Land Use in Figure 1-3, Section 1.1) from the atmosphere.[98]

Forests play a major role in New Hampshire's economy, environment, and quality of life. New Hampshire forests provide important functions such as wood and forest products, watershed protection, wildlife habitat, recreation, fall color, and maple sugar products. Sequestration of carbon through overall conservation of forest habitat and developing new forest habitat, particularly in urban areas, clearly protects these functions and helps to mitigate carbon dixoide emissions. However, increases in net sequestration due solely to changes in forest management practices are difficult to quantify and need to balance the multiple uses and benefits of forestlands. When reviewing the potential for increased carbon sequestration through management changes, it is also essential to understand and address leakage. Leakage is the unanticipated loss or gain of net greenhouse gas benefits beyond a sequestration project boundary, such as state boundaries.[99] With respect to New Hampshire forestry, this means that changes in management that result in less forest production may be compensated for out-of-state, and any greenhouse gas benefits may also be offset by increased out-of-state production of greenhouse gases.

Two means of maintaining and/or increasing carbon sequestration in New Hampshire's forestry sector are discussed in this section: 1) conservation of forest lands through avoided deforestation and creation of new urban and community forests, and 2) optimized forest management practices.

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[98] NH Department of Environmental Services, *The New Hampshire 1993 Greenhouse Gas Inventory*, October 1997, see http://www.des.state.nh.us/ard/ghgi/.

[99] Goldberg, D. 1998. *Carbon Conservation: Climate Change, Forests and the Clean Development Mechanism*, Washington, D.C.: Center for International Environmental Law.

7.2 Reduce Deforestation

New Hampshire's forestlands have declined by 134,500 acres (2.7%) since 1983 to about the same levels as 1948.[100] The loss of forested land at the rate of approximately 20,000 acres per year was largely the result of conversion of forests to housing and commercial uses, particularly in the southern part of the State. It is projected that an additional 2.5% of New Hampshire will be deforested by 2020.[101] Reducing this rate of deforestation represents a considerable climate change mitigation opportunity, through preservation of the existing forest and its carbon sequestration potential. If deforestation rates were reduced by 10,000 acres/year for the next 20 years, the potential carbon savings would be significant.[102]

TABLE 7-1. Potential Carbon Savings from Reducing Deforestation by 10,000 Acres Per Year

Assumptions:		
	Reduced Deforestation	10,000 acres/year
	(1 hectare = 2.47 acres)	4047 hectares/year
	Retained Biomass and Continued Uptake	124 tons carbon/hectare/year
Calculation:		
	4047 hectares/year x 124 tons carbon/hectare	
	= 501,828 tons carbon/year	
	= Over 10 million tons over 20 years	

Annually, averted deforestation could lower net State GHG emissions by almost 3%. While acknowledging that there is uncertainty involved in the above calculation, it employs conservative assumptions and represents a reasonable estimate of the effects of avoided deforestation on greenhouse gas emissions in the State. Given the commitment of the State and its citizens to try and minimize deforestation, the climate change benefits add one more argument for implementation of effective policies.

The Northeastern Area Urban and Community Forestry Program assists communities in planting and enhancing urban forests to improve the quality of life and sustainability of cities and towns. Foresters, planners, and the public work cooperatively to develop effective management strategies for urban forest resources to achieve the numerous co-benefits including: reducing heating and cooling costs of buildings (from shade programs), reducing stormwater discharge, and improving air quality.[103] These projects nearly always increase carbon sequestration as they

[100] USDA, Northeaster Research Station, NE-INF-141-00 *The Granite State's Forests: Trends in the Resource,* see http://www.fs.fed.us/ne/fia/states/nh/nhhilite.html.
[101] Society for the Protection of New Hampshire Forests, *New Hampshire's Changing Landscape,* 1999, see http://www.spnhf.org/eXplor/library.html.
[102] Rowland, D. 2001, Brown University Masters Thesis.
[103] For more information on the Northeastern Area Urban and Community Forestry Programs, see http://www.na.fs.fed.us/urban/urban.htm.

increase the forested area previously lost to development. Some New Hampshire projects include Manchester's Center City Green Neighborhoods and Vacant Lot Committee projects, park development in North Sandwich, and educational efforts in Gorham.

"Brownfields" programs are also a means of reducing deforestation. New Hampshire RSA 147-F, which became effective July 1, 1996, established a program to encourage the voluntary cleanup and redevelopment of contaminated properties (i.e., "Brownfields"). Brownfields are typically properties, which have been underutilized or abandoned due to environmental contamination. Historically, prospective new owners, financial institutions and municipalities have avoided involvement with these properties due to actual or potential liability for existing environmental contamination, typically caused by former site owners or operators. As a direct result, the unnecessary industrial development of pristine "greenfields," such as farms and forest lands, has occurred. DES's Brownfields program is designed to provide incentives for both environmental cleanup and redevelopment by persons who did not cause the contamination.[104]

The *Minimum Impact Development Partnership (MIDP)* is another prime example of a proactive program that can help reduce deforestation in the State. Started in 1999, with initial funding from a U.S. Environmental Protection Agency Sustainable Development Challenge Grant, MIDP is a collaboration between members of the development industry (e.g., developers, engineers, architects, bankers, insurers, builders), and natural and public health scientists. The project goal is to identify development practices that demonstrate sound land use and efficient use of energy, materials, and resources. Design experts and scientists develop and outline specific voluntary practices and performance standards for the building site, neighborhood, and town scales. Guidelines may be created to minimize deforestation in development projects, promoting house clustering and village design concepts. Through MIDP and other smart growth initiatives, New Hampshire can begin to realize the climate change benefits of reduced deforestation.

7.3 Improved Forest Management

The management of terrestrial carbon reservoirs may also be an important factor in plans to mitigate the impacts of elevated atmospheric carbon levels. Because forest management practices directly affect carbon sequestration levels, it is valuable to examine the potential for increased carbon sequestration as a result of forest management changes. As stated previously, forest management practices that increase carbon sequestration will also have to be balanced against the multiple uses and benefits of New Hampshire forestlands.

[104] For further information on DES' Brownfields programs, see http://www.des.state.nh.us/hwrb/hwrbbfld.htm.

Irland, et al. (1998) states that

> *…a superficial examination might lead to a conclusion that removing major stores of carbon through timber harvesting and converting it to a variety of products would lead to an overall loss in carbon storage." However, the impacts of harvesting activities depend upon the manner in which trees are harvested, the period of time over which the activities take place, and the future use to which wood products and the land is put. Timber harvests that maintain high tree volumes, optimal growth rates, and timber production result in superior levels of carbon sequestration. The potential benefits of forest management for carbon sequestration may only become apparent when considered over the life-span of trees and forest lands.*[105]

Measures taken today to enhance carbon sequestration will result in climate change benefits in the future.

Harvesting regimes that maintain high tree volumes, optimal growth rates, and timber production levels result in the highest levels of carbon sequestration. *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices in New Hampshire*[106] outlines many techniques for managing and maximizing timber quality. These techniques vary for different species and forest composition. However, generally single tree/small group selection practices sequester the most carbon, averaging between 285,000 and 362,000 lbs per acre.[107] When forest methods optimize size to encourage high-quality trees, only trees of a specific species and size are removed. Selective harvesting enables the volume of trees to remain high while maintaining timber production and providing conditions for continued growth.

With any harvesting practice, it is valuable to minimize soil erosion. Surface mineral soil conservation is a significant factor in managing for carbon sequestration because it comprises the bulk of soil carbon. Though soil carbon dynamics in response to different harvesting regimes are difficult to quantify, it is clear that erosion should be curbed to conserve soil carbon.

Management decisions about the removal of harvested tree components and the fate of the harvested material also have important carbon sequestration implications. A harvest can either be "stem only" or "whole tree." With a stem only harvest, the stems or trunks of trees are extracted while the rest of the tree is left to decompose. As its name implies, whole tree harvest means that the entire aboveground portion of the tree is extracted. On average, stem only

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[105] Irland, L. C., and Cline, M., June, 1998. Role of Northeastern Forests and Wood Products in Carbon Sequestration, p. 63.

[106] *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices in New Hampshire*, 1997 by the New Hampshire Division of Forest & Lands, DRED; and, the Society for the Protection of New Hampshire Forests.

[107] Rowland, D. 2001. Development of a New Hampshire Forestry Sector Carbon Emission Reductions Educational Web site Prototype. Brown University Masters Thesis.

harvesting results in the sequestration of 3 tons more carbon per acre than whole tree harvesting.[108] However, the fate of the low quality wood from "whole tree" harvesting also affects the generation of greenhouse gases. Biomass energy production from low-quality wood can also offset more carbon instensive fossil-fueled energy production.

There may be potential for increased carbon sequestration in New Hampshire's forestry sector. For example, recent research indicates that in a northern hardwood forest, changing from a 110 year clearcut harvest to a 75 year heavy-small diameter limited harvest on one acre of land would result in a 10 metric ton increase in carbon sequestration. Furthermore, switching the management of this same acre from a 75 year heavy-small diameter limit harvest to a single tree or group selection stem only harvest would result in an additional 3 tons of carbon storage. If every acre of New Hampshire forestland were able to be managed for maximum carbon storage in this fashion, an estimated 37 million metric tons of additional carbon could be sequestered in the State.[109] This potential increase represents approximately 11 times New Hampshire's annual net CO_2 emissions, though it is unclear how many years it would take to reach this level of sequestration.[110] By striving to integrate climate change considerations with other forest management objectives, the New Hampshire timber industry could play an increasingly beneficial role in New Hampshire's greenhouse gas budget.

Current use taxation in New Hampshire is intended to encourage preservation of open space. "Current use value means the assessed valuation per acre of open space land based upon the income-producing capability of the land in its current use, and not its real estate market value."[111] This method bases property taxation on the current use of the property and is intended to encourage, but not require, management practices. In addition to improved practices on managed forestlands, further incentives to incorporate land management practices, described within this chapter, in retained open space could significantly add to sequestration of carbon in New Hampshire. The State should continue to promote voluntary management actions on open space and should continue to support "current use taxation" to conserve and increase the productivity of these lands.

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[108] Ibid.
[109] Rowland, D. 2001. Development of a New Hampshire Forestry Sector Carbon Emission Reductions Educational Web site Prototype. Brown University Masters Thesis.
[110] NH Department of Environmental Services, *The New Hampshire 1993 Greenhouse Gas Inventory*, October 1997, see http://www.des.state.nh.us/ard/ghgi/.
[111] State of New Hampshire Revised Statutes Chapter 79-A, see http://sudoc.nhsl.lib.nh.us/rsa/79-A-2.htm.

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8. ROLE OF GOVERNMENT

8.1 Overview

The role of government is to help educate citizens about climate change, to provide incentives, and to remove barriers to actions that help reduce GHG emissions and mitigate the effects of climate change. While it is clear that actions taken in New Hampshire alone will not mitigate global impacts, it is the cumulative effect of local actions that will effect global climate change. The following sections describe actions the government can take to reduce its GHG emissions, and ways in which government can encourage businesses and individuals to take similar actions.

8.2 Greenhouse Gas Registry

In July 1999, Governor Shaheen signed into law the New Hampshire Greenhouse Gas Reduction Registry. This registry is intended to quantify and submit GHG emissions reduction actions to a state database for safekeeping against some future federal requirements. This approach was developed through a collaborative of business, government, and environmental leaders to encourage early reductions in GHG emissions. Prior experience under the federal Clean Air Act Amendments of 1990 led companies to be cautious about making voluntary GHG reductions. The emission reduction requirements required by the 1990 Amendments (basically percentage cuts) effectively rewarded sources that had been dirtier or slower to clean up because they started off with more, easier-to-reduce emissions. To avoid a potentially similar catch-22 with GHG emission reductions, the NH Registry was developed to ensure to the greatest extent possible appropriate recognition of voluntary actions taken by New Hampshire businesses, industries, and individuals to reduce GHG emissions. In the event that future GHG reduction targets are implemented, the NH Registry would help New Hampshire entities take credit for mitigation actions they have already taken.

Rules were recently promulgated under the New Hampshire Code of Administrative Rules, Chapter Env-A 3800 (*Voluntary Greenhouse Gas Emissions Reductions Registry*)[112] in accordance with NH RSA 125-L:3.[113] GHG emission reductions can be registered on a project basis (e.g., conversion of a boiler to natural gas) or as reductions from an entire company (i.e., whole company reporting). Whole company reporting is being encouraged as a way to establish a company's baseline emissions in any future regulatory scheme.

[112] NH Code of Administrative Rules, see http://www.des.state.nh.us/ard/ardrules.htm.
[113] State of NH Revised Statutes, see http://sudoc.nhsl.lib.nh.us/rsa/.

8.3 Energy Efficiency and Conservation

8.3.1 New Hampshire Building Energy Conservation Initiative (BECI)

In 1997, New Hampshire Governor Jeanne Shaheen announced the New Hampshire Energy Conservation Initiative for State Buildings. Over the last two years, the Energy Office has spearheaded this initiative, now known as the Building Energy Conservation Initiative (BECI).[114] New Hampshire has many state-owned buildings that have not implemented energy efficiency improvements. This provides opportunities for large energy cost savings and quick paybacks. Approximately 90% of state-owned buildings in New Hampshire have outdated lighting technology, and most are in need of heating/ventilation/air conditioning (HVAC) improvements, upgraded motors, HVAC controls, building envelope improvements, and operations and maintenance procedures designed to minimize energy consumption. With this building base, we can anticipate an opportunity to save from 20% - 40% on total energy consumption. The U.S. Environmental Protection Agency estimates 30% energy savings as typical for buildings in the Northeast.

The intent of the BECI initiative is to take advantage of this potential by analyzing state-owned buildings for energy and water savings opportunities, and retrofitting and upgrading where cost-effective opportunities exist, saving the state up to $8 million annually in energy costs. The program includes a survey of 500 state buildings for energy and resource conservation opportunities and then using guaranteed energy savings as the equity to secure financing for building upgrades.

Over the next several years, the State of New Hampshire will reduce its energy consumption by as much as 33 million kWh annually and CO_2 greenhouse gas emissions by up to 48 million pounds each year without incurring any capital expenses (due to energy savings from building upgrades).

This initiative provides a public example of good energy management and waste reduction, creates jobs for local people and companies, provides more comfortable work spaces, saves money, and reduces the environmental impact of the State's buildings. In three projects completed or contracted in 2001, an estimated 3 million kWh will be saved, reducing energy expenditures for the State by more than $200,000 and keeping 21,200 tons of CO_2 out of the atmosphere. Projects for which Request For Proposals (RFPs) have been issued for the next round anticipate energy cost reductions of $500,000 at 16 buildings comprising more than 300,000 square feet.

[114] Governor's Office of Energy and Community Service Building Energy Conservation Initiative, see http://www.state.nh.us/governor/energycomm/lowering/eprograms.html.

8.3.2 Performance Contracting for State Facility Construction

The State will implement building improvements through a process called Performance Contracting (see BECI, above). Performance contracting is a mechanism by which an Energy Service Company (ESCO) implements energy cost saving building improvements. Unlike the traditional contracting process, the performance contractor assumes project performance risk to guarantee to the building owner (state) that energy savings will be sufficient to pay for the project costs. In basic terms, this is paid from a savings program, and no up front capital costs are required to implement energy cost saving measures in state buildings. The State of New Hampshire, in NH RSA 21-I:19a-e,[115] allows state agencies to enter into performance contracts that achieve energy cost savings sufficient to recover any project costs or incurred debt service within 10 years from the date of project implementation (payback).

All state and municipally-owned building remodeling and new facility construction should be performed with consideration given to performance contracting.

8.3.3 State Energy Manager

A state energy manager position is included in the Governor's 2002-2003 budget and has been established in the Energy Office. The state energy manager will be responsible for managing a system of energy use and cost accounting to track state energy consumption; providing technical assistance for energy equipment procurement, maintenance and operations; providing technical assistance for building design development; and providing technical support to state agencies with performance contracts for energy improvements. The energy manager will realize cost savings for the State through the implementation of energy conservation and efficiency measures. This position will enable state government to demonstrate leadership in these areas while reducing the cost of government. Providing leadership for energy conservation and efficiency in state facilities would help stimulate these markets and provide actual demonstrations to the general public.

8.3.4 Cities for Climate Protection Campaign

The cities of Keene and Nashua are participating in the International Council of Local Environmental Initiatives (ICLEI) Cities for Climate Change Campaign.[116] ICLEI has been working with cities and counties since 1993 and currently works with over 350 cities and counties to reduce local emissions of greenhouse gases. In its first year of the program, Nashua will be conducting a baseline emissions inventory and forecast of emissions growth. Keene will implement various actions to reduce its local greenhouse gas emissions based on its previously conducted inventory. The State should continue to support these programs as they directly reduce greenhouse gas emissions by implementing energy efficiency and conservation measures, as well as addressing transportation and land use.

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[115] State of NH Revised Statutes, see http://sudoc.nhsl.lib.nh.us/rsa/.
[116] International Council of Local Environmental Initiatives (ICLEI) home page, see http://www.iclei.org/.

8.4 Land Use Planning

8.4.1 Promote Land Use Strategies that Serve To Reduce Fuel Use

Historically, land use planning strategies have encouraged urban sprawl (the expansion of urban areas further and further out from the urban center), which has led to increased dependence on the automobile. Commuting distances have significantly increased as more people are locating their homes in rural areas further and further away from their jobs. Local planning that separates commercial and residential areas into different "zoning districts" also encourages additional vehicle travel to shopping centers, malls, and other commercial businesses. As communities grow and physically spread out, vehicle miles traveled per household have increased. Land use patterns can be changed in ways that reduce vehicle miles traveled.[117] Examples include:

- Initiating impact fees, which require developers to pay for the portion of the infrastructure demands they generate.
- Adopting mixed-use zoning, which would allow greater accessibility to desired services without requiring greater mobility.
- Promoting development around transportation facilities, including transit stations, which allows communities to take advantage of existing infrastructure and offers improved accessibility.

8.4.2 GrowSmart NH

Governor Jeanne Shaheen in February 2001 launched GrowSmart NH, a comprehensive initiative aimed at helping New Hampshire combat sprawl and effectively manage growth. The initiative is intended to preserve open space, revitalize old, underused industrial lands, and to make smart growth a priority in state planning.[118] This initiative will include such things as: redevelopment of brownfield sites, providing grants to communities to protect their water supply lands from development, planning grants for smart growth initiatives, and better state agency planning. As part of these efforts, Governor Shaheen signed into law "smart growth" as a state policy and established a Growth Management Advisory Committee to conduct a statewide study of sprawl that will recommend "smart growth" policies for New Hampshire to protect natural resources and strengthen the economy.

8.4.3 Minimum Impact Development Partnership (MIDP)

The Minimum Impact Development Partnership (MIDP), started in 1999 with initial funding from an U.S. Environmental Protection Agency Sustainable Development Challenge Grant, is a collaboration between members of the development industry (e.g., developers, engineers, architects, bankers, insurers, builders) and natural and public health scientists to identify preferable development practices. Its goals are to identify development practices that

[117] For examples of land use strategies which reduce fuel use, see http://www.mdp.state.md.us/smartgrowth/smartwhat.htm.
[118] For further information, see http://www.state.nh.us/governor/growsmart.html

demonstrate sound land use and efficient use of energy, materials, and resources. Such practices minimize air, land and water pollution, energy use, and habitat loss from development.[119]

In terms of transportation design elements, minimum impact would involve promoting public transportation, reducing vehicle miles traveled, and providing good access to walkways and bike paths. Design experts and scientists will describe specific voluntary practices, with performance standards, at the building, site, neighborhood, and town scales. The MIDP also will identify measures of progress toward minimum impact development, and highlight "leading by example" case studies that do so.

8.4.4 Adaptive Measures in Local Planning

Although an essential part of regional and national reductions, the successful implementation of *The Climate Change Challenge* will only address a portion of the problem of globally increasing concentrations of greenhouse gases in the atmosphere. Due to the uncertainty of corresponding actions on a worldwide basis, and the lengthy response time necessary for climate actions to have an impact, it is also prudent for local government to undertake adaptive measures to mitigate the potential impacts of climate change. Adaptive measures may include adjusting building codes, infrastructure rehabilitation (particularly in coastal areas), and measures to address potential shifts in agriculture and forestry. For example, designing and building any new infrastructure should consider potential sea level changes and increased storm severity and events.

8.5 Education and Outreach

Public education and outreach will be a critical component of *The Climate Change Challenge.* This effort needs to be integrated with the many public and non-profit organizations working in energy conservation and climate change issues. Education and outreach efforts should inform the public on the science of global climate change, the potential impacts, and mitigation strategies to reduce GHG emissions. The DES climate change website should be enhanced to provide information and links to energy efficiency information, alternative technologies and fuels, grants, organizations, and programs available to assist the commercial/industrial and residential sectors. New Hampshire should develop public outreach plans by sector (i.e., transportation, commercial/industrial and residential) that promote and coordinate efforts by the DES, Energy Office, Department of Transportation, and other state and local agencies. New Hampshire has provided and should continue to provide materials for climate change curricula to the public school system and other education-focused groups such as the New England Science Centers Collaborative. Other key areas to target are described below.

[119] Center for Livable Communities, see http://www.lgc.org/center/

8.5.1 New Hampshire Local Impact Assessment Project (LIAP)

The New Hampshire Local Impact Assessment Project (LIAP) was sponsored by the DES, through a grant commissioned by EPA's Climate Change Division, to enhance the public knowledge of global climate change. LIAP was designed to evaluate the potential impacts of climate change on a local basis, with a specific emphasis on New Hampshire's forest and water resources. Since a large portion of New Hampshire's economy is tied to our natural resources, particularly water and forest resources, it is important that government, businesses, and individuals obtain a firm understanding of the current science and consider the potential changes that may occur to our water and forest resources as a result of climate change. The first step of LIAP was to compile the latest scientific information on global climate change as it applies to New Hampshire, and analyze its potential ecological and economic effects in the State – particularly as it may affect water and forests. The resulting information and analysis was provided to a diverse group of stakeholders in the forest and water communities to obtain feedback, and to begin a joint discussion of ways to reduce potential risk from climate change by mitigating or adapting to global climate change. The final report summarizing the LIAP process, local impacts from climate change, and the forest and water stakeholders' participation and input will be published by December of 2001. The results of this project will continue to be used in New Hampshire's education and outreach efforts.

8.5.2 Initiate a Consortium for Sustainable Transportation

A coordinating committee from industry, Energy Office, DES, the Office of State Planning, NH Department of Transportation, University of New Hampshire, municipalities and local officials, should initiate a research and development consortium to spearhead pilot programs in "sustainable transportation." This consortium should address the need to lower emissions from the transportation sector and the opportunities for job creation in alternative transportation.

The consortium could build partnerships with the U.S. Department of Energy, U.S. Environmental Protection Agency, U.S. Department of Transportation and industry (through the U.S. Environmental Protection Agency Climate Wise Program) to fund pilot studies, demonstration projects, and research.

8.5.3 Implement Public-Private Partnership for Research and Development

A public-private research and development partnership should be formed under the leadership of the Office of State Planning, Energy Office, New Hampshire Department of Resources and Economic Development and private entities for the purpose of creating and fostering new business opportunities based on alternative fuels and energy conservation technologies.

DES, in conjunction with the Energy Office, should develop an educational outreach program about applications of alternative energy technologies.

8.5.4 Rebuild New Hampshire

Rebuild New Hampshire, a full partner with the US Department of Energy's Rebuild America program, assists communities, institutions, public school systems, municipal governments, public housing agencies, and other entities responsible for buildings to plan, finance, and implement energy efficiency and renewable energy projects in their buildings.[120] Rebuild New Hampshire is a partnership program providing technical assistance through consultations, workshops, and resource materials, to guide building owners toward reduced energy use, lower energy costs, and improved environmental performance. Eleven communities recently were awarded grants totaling $90,000. Rebuild New Hampshire also provides guidance to towns and cities seeking to reduce energy costs through the use of performance contracting (see Section 8.3.2 for more information). In addition, as part of this initiative, Rebuild America is revising and updating the energy related portions of the state Department of Education's guidelines for school construction and remodeling (see Section 8.5.6). New Hampshire should continue to promote this program and help them secure funding for energy efficiency improvements.

8.5.5 School Programs

The EnergySmart Schools[121] and Green Schools Programs, sponsored by the federal Department of Energy and the Alliance to Save Energy, [122] respectively, are initiatives to make schools more energy efficient and more environmentally responsible. The Energy Office enlists schools for these programs.

Savings Through Energy Management (STEM) is a program facilitated by the Energy Office where junior high and high school students learn to perform energy audits at their own schools, and present energy savings recommendations to their school boards. This initiative helps schools identify what they can do to reduce energy costs (and GHG emissions), and helps educate students on the merits of energy conservation and efficiency.

The New Hampshire Solar on Schools program, a public-private partnership involving the Energy Office and Public Service Company of New Hampshire, assists schools in purchasing solar electric (photovoltaic) systems to produce clean, renewable energy on-site, and integrating materials on renewable energy technologies with science and math curricula. By the spring of 2001, 13 schools in New Hampshire had these systems in place, serving a variety of energy and educational needs. New Hampshire should continue to enlist schools in these programs and help them secure funding for energy efficiency improvements and education.[123]

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[120] For more information about Rebuild America, see http://www.rebuild.org/.
[121] Energy Smart Schools, see http://www.eren.doe.gov/energysmartschools/teach_stuff.html.
[122] The Alliance to Save Energy, see http://www.ase.org/.
[123] For more information on schools going solar, see http://www.schoolsgoingsolar.org/.

8.5.6 High Performance Schools

New Hampshire Partnership for High Performance Schools is working to upgrade the energy efficiency of design and construction decisions regarding school building projects, whether new or renovations. The Energy Office and the New Hampshire Department of Education are focusing on the rationale and techniques for financing higher efficiency equipment and design solutions in a voluntary approach to making schools more energy efficient, cheaper to operate, less environmentally polluting, and more productive and comfortable spaces for educational activities.

APPENDIX A

The Climate Change Challenge Work Group

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The Climate Change Challenge Workgroup

In compiling The Climate Change Challenge, a workgroup comprised of interested parties from business, industry, state agencies, the environmental community, and others was established to bring the issue of climate change to their attention and to draw from their knowledge and experience in formulating the plan. Mitigation strategies were focused on transportation, electricity demand side (residential, industrial, commercial), electricity supply side (utilities), carbon sequestration, and the role of government. Mitigation strategies were selected based on the amount of greenhouse gas emissions reduced, the type of approach (legislative, market driven, educational, governmental policy), political feasibility, ancillary benefits and costs, flexibility, and institutional capacity. Various mitigation strategies were compiled and are discussed in Chapter 3 through 8. These strategies comprise the selected strategies that represented a cost-effective, practical, and feasible voluntary approach. Workgroup participants included:

Susan Arnold	Governor Jeanne Shaheen's Office
Carol Barleon	New Hampshire Office of State Planning
Barbara Bernstein	New Hampshire WasteCap Recon
Laurel Brown	Public Service of New Hampshire (Northeast Utilities)
Robert Cheney	Sheehan, Phinney, Bass & Green
Ray Danforth	formerly with Crown Vantage
Paul Doscher	Society for the Protection of New Hampshire Forests
Richard Eidlin	Solar Works, formerly with Advanced Energy Systems
Kent Finemore	New Hampshire Department of Environmental Services
Joe Fontaine	New Hampshire Department of Environmental Services
Donna Gamache	formerly Senator Bob Smith's Office
Tracy Guyette	New Hampshire Public Utilities Commission
David Harrington	formerly with New Hampshire Petroleum Council
Kate Hartnett	NH Comparative Risk Project/Minimum Impact Development Partnership
Tom Kelly	University of New Hampshire Office of Sustainability Programs
Nelson Lebo	Proctor Academy, New Hampshire Environmental Educators
Jeff MacGillivray	Former NH State Representative
David Marshall	Conservation Law Foundation
Joanne Morin	New Hampshire Department of Environmental Services
Jan Pendlebury	New Hampshire Climate Change Coalition, formerly with NH Citizens Alliance
Vincent Perelli	New Hamphsire Department of Environmental Services
Robert Pickering	formerly Public Service of New Hampshire (Northeast Utilities)
Richard Polonsky	Innovation Works/Environmental Defense
Barry Rock	University of New Hampshire Complex Systems Research Center
William Roy	New Hampshire Department of Transportation
Jack Ruderman	New Hampshire Governor's Office of Energy & Community Services
Kerry Scarlott	Sheehan, Phinney, Bass & Green
Robert Sculley	New Hampshire Motor Transport Association
Allan Silber	New Hampshire Air Resources Council
Judy Silverberg	New Hampshire Department of Fish & Game
Dick Uncles	New Hampshire Department of Agriculture
Robert Varney	New Hampshire Department of Environmental Services
Henry Veilleux	formerly with New Hampshire Business and Industry Association
David White	New Hampshire Railroad Revitalization Association
Julian Zelazny	Audubon Society of New Hampshire

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APPENDIX B

Summary of New Hampshire Greenhouse Gas Mitigation Strategies

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TABLE B-1: Power Generation Mitigation Strategies

Section	Mitigation Strategy	Coordinating Agencies/Group	Date	Related Websites
4.1	*New Hampshire Clean Power Strategy* (CPS) An Integrated Strategy to Reduce Emissions of Multiple Pollutants from New Hampshire's Electric Power Plants	DES, PUC	2001-2002 Legislative Session	http://www.des.state.nh.us/ard/NHCPS_draft.pdf
4.2	Environmental Disclosure Rules as part of deregulation of retail electricity market	PUC	Last half 2001	http://www.rapmaine.org/disclose.html
4.3	Promote completion of two new gas-fired combined cycle power plants	DES, PUC, DRED	On-going 2001-2003	http://www.aesgraniteridge.com/ under construction - http://www.resourcesolutions.org/
4.4.2	Promote Photovoltaic Systems	ECS, DES	On-going	http://www.nrel.gov/ncpv/
4.4.3	Landfill Gas to Energy Project	ECS, DES, WasteCap	2002-2004	http://www.eren.doe.gov/cities_counties/landfil.html
4.4.4	NH Wind Study Project	ECS, DES	2002-2004	http://www.awea.org/default.htm
4.4.5	Geothermal Energy Feasibility Study	ECS, DES	2002-2004	http://www.eren.doe.gov/RE/geothermal.htmland http://yosemite1.epa.gov/estar/consumers.nsf/content/ghp.htm
4.4.6	Green Power Pricing	ECS, DES	2002-2004	http://www.green-e.org/ and http://www.rapmaine.org/green.html
4.5	Use of Nuclear Power	ECS, DES, PUC, BIA	2002-2004	

DES – New Hampshire Department of Environmental Services
ECS – Governor's Office of Energy and Community Services
DOT – New Hampshire Department of Transportation
PUC – New Hampshire Public Utilities Commission
DRED- New Hampshire Department of Resource and Economic Development
BIA – Business & Industry Association of NH
DOS – New Hampshire Department of Safety

TABLE B-2: Efficiency and Conservation Mitigation Strategies

Transportation					
	Section	**Mitigation Strategy**	**Coordinating Agencies/Group**	**Date**	**Related Websites**
Promote Existing Programs	3.2.2	NH Carpooling Programs and Use of Public Transit	DOT	On-going	http://webster.state.nh.us/dot/rideshare/index.html
	3.2.4	Expand and Promote Bikeways and Walkways	DOT, ECS, DES	2002-2003	http://www.massbike.org/
	3.2.5	Promote Telecommuting and Alternative Work Schedules	DES, ECS, DOT, OSP, BIA	2002-2003	
	3.3.2	Enhanced Vehicle Inspection and Maintenance	DOS, DES	On-going	http://webster.state.nh.us/safety/9799mv.html
	3.3.3	On-Road Diesel Opacity Testing	DOS, DES	On-going	http://webster.state.nh.us/safety/9799mv.html
	3.3.5	Green Car Labeling	DES & NH Automobile Dealers Assoiciation	On-going	
	3.2.8	NH Rideshare Program for State Employees	DES, DOT	On-going	http://webster.state.nh.us/dot/rideshare/index.html

DES – New Hampshire Department of Environmental Services
ECS – Governor's Office of Energy and Community Services
DOT – New Hampshire Department of Transportation
PUC – New Hampshire Public Utilities Commission
DRED- New Hampshire Department of Resource and Economic Development
BIA – Business & Industry Association of NH
DOS – New Hampshire Department of Safety
OSP – Office of State Planning

TABLE B-2 (continued): Efficiency and Conservation Mitigation Strategies

Transportation (continued)					
	Section	**Mitigation Strategy**	**Coordinating Agencies/Group**	**Date**	**Related Websites**
Provide Institutional Support	3.3.1	Advocate Raising the Federal CAFE Standard	DES, EPA	On-going	www.epa.gov/otaq/fetrends.htm http://www.fueleconomy.gov/ , http://www.greenercars.com/indexplus.html http://www.epa.gov/orcdizux/cert/feguide/fegsear.htm
	3.2.3	Passenger Rail Revitalization	DOT, DES, DRED	On-going	http://www.state.nh.us/dot/10418c/raildoc.htm http://www.state.nh.us/dot/10418c/default.htm http://www.dot.gov/affairs/fra2000.htm http://trainweb.org/nhrra/
	3.3.4	On-Board Diagnostics Inspections	DOS, DES	On-going	http://www.des.state.nh.us/factsheets/ard/ard-30.htm
	3.3.6	Clunker Car Retirement	DOS, DES	2002-2003	
Longer Term Initiatives	3.2.1	Integrated Transportation Planning	NH Integrated Transportation and Rail Advisory Council	On-going	http://www.state.nh.us/governor/media/051700transportation.html http://trainweb.org/nhrra/
	3.2.7	State Government Transportation Demand Management Plan	DES, DOT, ECS	2002-2003	
	3.2.6	Promote Pricing Measures which Reduce VMT	DES, Office of State Planning	2003-2004	

DES – New Hampshire Department of Environmental Services
ECS – Governor's Office of Energy and Community Services
DOT – New Hampshire Department of Transportation
PUC – New Hampshire Public Utilities Commission
DRED- New Hampshire Department of Resource and Economic Development
BIA – Business & Industry Association of NH
DOS – New Hampshire Department of Safety

TABLE B-2 (continued): Efficiency and Conservation Mitigation Strategies

Commercial/Industrial					
	Section	**Mitigation Strategy**	**Coordinating Agencies/Group**	**Date**	**Related Websites**
Promote Existing Programs	5.2.1	Energy Star Programs	DES, ECS, EPA, BIA	On-going	http://www.energystar.gov/
	5.2.2	Small and Cool Initiative	DES, ECS, Clean Air-Cool Planet	On-going	http://www.cleanair-coolplanet.org
	5.2.3	Industries of the Future	DES, ECS, BIA	On-going	http://www.wastecapnh.org/
Provide Institutional Support	5.2.4	Commercial/Industrial Energy Codes and System Benefit Charges	DES, ECS, State Fire Marshall	On-going	
Longer Term Initiatives	5.2.5	Load Response Programs	DES, ECS, PUC	On-going	http://www.iso-ne.com/main.html

DES – New Hampshire Department of Environmental Services
ECS – Governor's Office of Energy and Community Services
DOT – New Hampshire Department of Transportation
PUC – New Hampshire Public Utilities Commission
DRED- New Hampshire Department of Resource and Economic Development
BIA – Business & Industry Association of NH
DOS – New Hampshire Department of Safety

TABLE B-2 (continued): Efficiency and Conservation Mitigation Strategies

Residential					
	Section	**Mitigation Strategy**	**Coordinating Agencies/Group**	**Date**	**Related Websites**
Promote Existing Programs	6.2.3	EPA's Energy Star Homes Program	DES, ECS, EPA	On-going	http://yosemite1.epa.gov/estar/homes.nsf/HomePage?OpenForm
	6.2.4	Department of Energy Weatherization Assistance Program	ECS	On-going	http://webster.state.nh.us/governor/energycomm/assist.html
	6.4.3	Recycling Programs	DES	On-going	http://www.des.state.nh.us/hhw/
Provide Institutional Support	6.2.1	Residential Energy Codes and System Benefit Charges	ECS, State Fire Marshall	On-going	http://webster.state.nh.us/governor/energycomm/sep.html
	6.2.2	Appliance and Equipment Standards	DES, EPA	2002-2003	
	6.2.5	Wood Stove Retirement/Replacement	DES, ECS, SPNHF, NH Timberland Assoc.	2002-2004	http://wlapwww.gov.bc.ca/air/particulates/rwssabi.html.
Longer Term Initiatives	6.2.6	Financing Programs	DES, ECS	2003-2005	

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ECS – Governor's Office of Energy and Community Services
DOT – New Hampshire Department of Transportation
PUC – New Hampshire Public Utilities Commission
DRED- New Hampshire Department of Resource and Economic Development
BIA – Business & Industry Association of NH
DOS – New Hampshire Department of Safety
SPNHF – Society for Protection of NH Forests

TABLE B-3: Alternative Energy, Technology, and Fuels Mitigation Strategies

Transportation					
	Section	**Mitigation Strategy**	**Coordinating Agencies/Group**	**Date**	**Related Websites**
Promote Existing Programs	3.4.1	Clean Cities Program	DES, ECS, DOT	On-going	http://www.ccities.doe.gov/
	3.4.5	Promote Alternative Fuels at Manchester Airport	DES, DOT, Manchester Airport Authority	On-going	http://www.afdc.nrel.gov/ http://afdc3.nrel.gov/documents/altfuelnews/
	3.4.6	Promote Improved Marine Engines	DES, EPA, NH Marine Dealers	On-going	
Provide Institutional Support	3.4.2	Promote and Expand Use of Electric Vehicles	DES, ECS, DOT	On-going	http://www.des.state.nh.us/ard/mobilesources http://www.afdc.nrel.gov/ http://afdc3.nrel.gov/documents/altfuelnews/ http://homepages.ihug.co.nz/~don_s/alternatefuelslpg.htm
	3.4.3	Promote and Expand Use of Natural Gas Powered Vehicles	DES, DOT, ECS, and other state agencies	On-going	http://naturalfuels.com/vehicles.htm http://homepages.ihug.co.nz/~don_s/alternatefuelslpg.htm
	3.4.4	Promote and Expand the Use of Hybrid Vehicles	DES, DOT, ECS, and other state agencies	On-going	http://www.navc.org/link1.html

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ECS – Governor's Office of Energy and Community Services
DOT – New Hampshire Department of Transportation
PUC – New Hampshire Public Utilities Commission
DRED- New Hampshire Department of Resource and Economic Development
BIA – Business & Industry Association of NH
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TABLE B-3 (continued): Alternative Energy, Technology, and Fuels Mitigation Strategies

Commercial/Industrial					
	Section	**Mitigation Strategy**	**Coordinating Agencies/Group**	**Date**	**Related Websites**
Promote Existing Programs	5.3.2	Promote Expansion/Use of Natural Gas	DES, ECS	On-going	
	5.3.6	Purchase of Renewable Energy Resources	DES, ECS	On-going	http://www.state.nh.us/governor/energycomm/eir.html http://www.rapmaine.org/disclose.html http://www.irecusa.org/
	5.3.7	Million Solar Roofs Initiative	DES, ECS	On-going	http://www.eren.doe.gov/millionroofs/ http://www.state.nh.us/governor/energycomm/sep/solarroofs.html
Provide Institutional Support	5.3.1	Promote the Use of Combined Heat and Power – Cogeneration	DES, ECS, BIA	On-going	http://www.nemw.org/uschpa/index.htmll
	5.3.3	Conversion of Industrial Oil-Fired Boilers to Natural Gas	DES, ECS, BIA	On-going	
	5.3.4	Co-Firing with Biomass and Gas	DES, ECS	On-going	
	5.3.5	Distributed Power Generation	DES, ECS, PUC	On-going	http://www.distributed-generation.com/Library/Cogeneration_in_Manufacturing.htm

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TABLE B-3 (continued): Alternative Energy, Technology, and Fuels Mitigation Strategies

Residential					
	Section	**Mitigation Strategy**	**Coordinating Agencies/Group**	**Date**	**Related Websites**
Promote Existing Programs	6.3.1	Million Solar Roofs Initiative	DES, ECS	On-going	http://www.eren.doe.gov/millionroofs/ http://www.state.nh.us/governor/energycomm/sep/solarroofs.html http://www.ases.org/
	6.3.2	Purchase of Renewable Energy Resources	DES, ECS	On-going	http://www.state.nh.us/governor/energycomm/eir.html http://www.rapmaine.org/disclose.html http://www.irecusa.org/
Provide Institutional Support	6.3.3	Promote Conversion to Natural Gas	DES, ECS	On-going	
	6.3.4	Promote Geothermal Options	DES, ECS	On-going	http://yosemite1.epa.gov/estar/consumers.nsf/content/ghp.htm

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TABLE B-4: Waste Management and Efficiency Mitigation Strategies

Commercial/Industrial				
Section	**Mitigation Strategy**	**Coordinating Agencies/Group**	**Date**	**Related Websites**
5.4.2	Phase-out of Ozone-Depleting Substances	EPA	On-going	http://www.epa.gov/ozone/index.html
5.4.2	DES Pollution Prevention Programs	DES	On-going	http://www.des.state.nh.us/nhppp/
5.4.3	Green Lodging Initiative	DES	On-going	http://www.des.state.nh.us/pcas/
Residential				
6.4.2	Phase-out of Ozone-Depleting Substances	EPA	On-going	http://www.epa.gov/ozone/index.html
6.4.3	Recycling Programs	DES	On-going	http://www.des.state.nh.us/hhw/

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TABLE B-5: Carbon Storage and Sequestration Mitigation Strategies

Section	Mitigation Strategy	Coordinating Agencies/Group	Date	Related Websites
7.2	Reduce Deforestation	DES, DRED, SPNHF	2003-2005	http://www.des.state.nh.us/ard/ghgi/ http://www.fs.fed.us/ne/fia/states/nh/nhhilite.html http://www.spnhf.org/eXplor/library.html http://www.na.fs.fed.us/urban/urban.htm http://www.des.state.nh.us/hwrb/hwrbbfld.htm
7.2	Minimum Impact Development Partnership	Partnership members, Office of State Planning	On-going	
7.3	Improved Forest Management Practices	DES, DRED, SPNHF	2003-2005	Irland, L. C., and Cline, M., June, 1998, Role of Northeastern Forests and Wood Products in Carbon Sequestration, p. 63. Rowland, D. 2001. Development of a New Hampshire Forestry Sector Carbon Emission Reductions Educational Web site Prototype. Brown University Masters Thesis. Goldberg, D. 1998. *Carbon Conservation: Climate Change, Forests and the Clean Development Mechanism*, Washington, D.C.: Center for International Environmental Law. *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices in New Hampshire*, 1997 by the New Hampshire Division of Forest & Lands, DRED; and, the Society for the Protection of New Hampshire Forests.
7.3	Current Use Taxation	DES, DRED, Office of State Planning	2003-2005	http://sudoc.nhsl.lib.nh.us/rsa/79-A-2.htm

DES – New Hampshire Department of Environmental Services
SPNHF – Society for Protection of NH Forests
PUC – New Hampshire Public Utilities Commission
ECS – Governor's Office of Energy and Community Services
DRED- New Hampshire Department of Resource and Economic Development

TABLE B-6: Role of Government

	Section	Mitigation Strategy	Coordinating Agencies/Group	Date	Related Websites
Promote Existing Programs	8.2	Greenhouse Gas Registry	DES, BIA	On-going	NH Code of Administrative Rules, see http://www.des.state.nh.us/ard/ardrules.htm State of NH Revised Statutes, see http://sudoc.nhsl.lib.nh.us/rsa/
	8.3.1	NH Building Energy Conservation Initiative (BECI)	ECS, DES	On-going	http://www.state.nh.us/governor/energycomm/sep/beci.html
	8.3.2	Performance Contracting for State Facility Construction	NH Dept. of Administrative Services	On-going	
	8.3.3	State Energy Manager	ECS, DES	Pending 2001-2002 legislation	
	8.3.4	Support Cities for Climate Protection Campaign	DES, ECS	On-going	http://www.iclei.org/
	8.4.1	Promote Land Use Strategies that serve to Reduce Fuel Use	DES, ECS, DOT, Office of State Planning	On-going	http://www.mdp.state.md.us/smartgrowth/smartwhat.htm
	8.4.2	GrowSmart NH	Office of State Planning, DES, DRED	On-going	http://www.state.nh.us/governor/growsmart.html
	8.4.3	Minimum Impact Development Partnership (MIDP)	DES, ECS, DRED, Office of State Planning	On-going	http://www.lgc.org/center/index.html
	8.4.4	Adaptive Measures in Local Planning	Planning Departments		

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TABLE B-6 (continued): Role of Government

	Section	Mitigation Strategy	Coordinating Agencies/Group	Date	Related Websites
Education and Outreach	8.5.1	Local Assessment Impact Project	DES	Complete by 10/2001	
	8.5.2	Initiate a Consortium for Sustainable Transportation	DES, ECS, DOT	2002-2003	
	8.5.3	Implement Public-Private Partnership for Research and Development	DES, ECS, BIA	2002-2003	
	8.5.4	Rebuild New Hampshire	DES, ECS	On-going	http://www.rebuild.org/
	8.5.5	School Programs	DES, ECS, Department of Education	On-going	http://www.eren.doe.gov/energysmartschools/teach_stuff.html http://www.ase.org/ http://www.schoolsgoingsolar.org/
	8.5.6	High Performance Schools	DES, ECS, Department of Education	On-going	

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APPENDIX C

Glossary of Terms

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Anthropogenic emissions – Emissions of greenhouse gases from man-made processes such as energy use.

BECI – New Hampshire Building Energy Conservation Initiative

Carbon sequestration – Refers to the storage of carbon in various forms, primarily plant life. Forests represent a significant reservoir of carbon. Carbon is sequestered, or stored, in plants and trees through photosynthesis. Hence, as trees develop and forests mature the amount of carbon stored increases.

Climate Change – Refers to changes in the complex interaction between the sun's energy, and the oceans, continents, atmosphere, and living things that drive the earth's climate.

CFCs – Chlorofluorocarbons, miscellaneous greenhouse gases. Manmade chemicals used as refrigerants and other heat transfer fluids, foaming agents, propellants, fire extinguishers, and solvents. See HCFCs and PFCs.

CH_4 – Methane, a primary greenhouse gas. Sources include fugitive emissions from natural gas distribution, emissions from decomposition at landfills and digestion processes by ruminants.

CMAQ – Congestion Mitigation and Air Quality

CO_2 – Carbon dioxide, a primary greenhouse gas. It is largely a product of combustion and respiration. It is also an emission product of combustion of a carbon-based fuel (i.e., gasoline, oil, natural gas, coal, and wood).

DES – New Hampshire Department of Environmental Services

Emission – In this report, emission refers to the production and transfer of a greenhouse gas to the atmosphere over and above natural greenhouse gas fluxes.

Energy Office – New Hampshire Governor's Office of Energy and Community Services

EPA – United States Environmental Protection Agency

GFCC – Gas-fired combined cycle

GHG – Greenhouse gas

Greenhouse effect – The natural phenomenon in the Earth's atmosphere that slows down the loss of heat from the surface of the Earth to outer space. Some of the sun's energy that is radiated back from the earth's surface is absorbed by certain gases (known as "greenhouse gases") present in the atmosphere, causing a warmer surface temperature than would otherwise be possible. The Greenhouse Effect is essential to life on earth.

Greenhouse gas – Any of several gases that absorb heat energy. Naturally occurring greenhouse gases are water vapor, CO2, methane, nitrous oxide, and ozone. These are also produced by manmade sources. Manmade greenhouse gases include chlorofluorcarbons (CFCs), hydrochlorofluorocarbons (HCFCs), perfluorocarbons and (PFCs)..

GSEC – Granite State Electric Company

GWP – Global Warming Potential is defined as the ratio of global warming effect of a greenhouse gas to that of carbon dioxide. For example, a GWP for methane of 21 indicates that actual methane emissions would be multiplied by 21 to express the concentration of carbon dioxide emissions that would have an equivalent greenhouse gas effect.

HCFCs – Hydrochlorofluorocarbons, a miscellaneous greenhouse gas, including chlorofluorcarbons (CFCs), halons, methyl chloroform, carbon tetrachloride, methyl bromide, and hydrochlorofluorocarbons (HCFCs). Sources include refrigerants and other heat-transfer fluids, propellants, air conditioners and other cooling equipment, foaming agents, fire extinquishers, and solvents. See CFCs and PFCs.

IPCC –Intergovernmental Panel on Climate Change, an international group of thousands of scientists that was established by the United Nations Environment Programme and the World Meteorological Organization in1988 to assess scientific information about climate change relevant to international and national policy formation.

MIDP – Minimum Impact Development Partnership

MSRI – Million Solar Roofs Initiative

N_2O – Nitrous oxide, a primary greenhouse gas, emitted from internal combustion of fuels, vehicle catalytic converters, and nitrogen-based fertilizer.

NESEA – Northeast Sustainable Energy Association

NHDOT – New Hampshire Department of Transportation

NHEC – New Hampshire Electric Cooperative

NHRRA –New Hampshire Rail Revitalization Association

OBD – "On-board diagnostics" systems were installed in vehicles starting in 1996 and allow for a comprehensive inspection of the emissions control system by plugging a scan tool into a vehicle's universal OBD port.

O_3 – Ground-level ozone is formed from the combination of a number of man-made

emissions – volatile organic compounds, nitrogen oxides and carbon monoxide. These compounds react with oxygen in the air in the presence of heat and strong sunlight to produce ground-level ozone, the primary ingredient of smog. Unlike ozone in the upper atmosphere, which is naturally occurring and beneficial due to its protective qualities, ozone at the earth's surface is a man-made air pollutant, which can have harmful effects on both humans and the environment.

Opacity – In reference to opacity of a vehicle's exhaust, the percentage of background light obscured by the vehicle's exhaust.

PFCs – Perfluorocarbons, a miscellaneous greenhouse gas. Sources include refrigerants and other heat-transfer fluids, air conditioners and other cooling equipment, foaming agents, fire extinquishers, and solvents. See CFCs and HCFCs.

PSNH – Public Service of New Hampshire

PUC – New Hampshire Public Utility Commission

PV systems – Solar photovoltaic systems convert the sun's light into electricity. This electricity can be used directly, stored in batteries, or fed into an electric utility's grid system.

Residual oil – Heavy oils remaining after the distillation process, generally having a high sulfur content. These oils are used as fuels in larger industrial and commercial operations.

Ruminants – Animals with multi-chambered stomachs that allow for digestion of extremely course and low nutrient forages, such as grass and straw. This unique digestive pathway of ruminants, namely cattle, deer, and camels, produces large amounts of methane.

SBC – Systems benefits charge is a mandated charge by a regulated electric utility that establishes a fund for such things as low-income assistance or energy efficiency.

Sequestration – See carbon sequestration.

SF_6 – Sulfur hexafluoride, a miscellaneous greenhouse gas, is largely used in heavy industry as an electric insulator, also used in high-voltage equipment and cable cooling systems.

Sink – In biogeochemical terms, a sink is something that stores or sequesters an element. It removes it from circulation. Relative to climate change, sinks are usually referred to in terms of carbon stored or "sequestered."